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(3) silk substitutes

(4) indian silk industry

(5) silkworms (10) silk weaving

(6) mulberry (11) indian silk production

(7) raw silk

(8) reeling

(9) silk industry byproducts

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C.S.I.R. MONOGRAPH

SILK PRODUCTION AND WEAVING IN INDIA

By

C. C. GHOSH

Year 1949

Council of Scientific and Industrial Research.

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PREFACE.

This monograph is written at the request of the Director of the Board of Scientific and Industrial ·earch. It deals in detail with silk proper and gives a general account of *tasar*, *muga* and *eri* silks well as of rayon (formerly known as artificial silk) in order to enable readers to form an idea of relationships of them all and how far they can be developed.

Regarding details of treatment of the subject the productive stages of the silk industry, commonly erstood as sericulture upto production of the raw silk thread have been dealt with in thorough details hat the publication may be of use to those who intend starting sericulture in new areas or improving culture where it exists. The enquiries from various parts of India which the writer had to attend luring the years since 1936 he has been in the charge of the Sericultural Department of Bengal and erly as Special Officer, have convinced him of the necessity of such information being made available ne publication which may be of help to the general reader as well as to the sericultural departments he various provinces and States of India. Recently some interest in this respect though not quite cient or on a scale comparable to the efforts of Japan, has been taken in the sericultural industry ndia. The two Tariff Boards which enquired into this industry recently have brought together published a good deal of information. As a result of the recommendation of the first Board an ›erial Sericultural Committee has been set up as an adjunct to the Board of Industries and meets ually mainly to distribute the grant of Rs. 100,000 between various provinces. At the suggestion he writer made through the Government of Bengal an All-India Sericultural Conference has been ıgurated where the sericultural experts and workers engaged in the industry meet and discuss ›lems. It held two sessions and has published the reports of these meetings.

In Bengal, research had been organised since about 1938 by the writer though on a limited scale he improvement of mulberry, worms and cocoons and control of diseases of worms. This nucleus now been further strengthened and taken over by the Government of India and converted into the ral Sericultural Research Station with the main station at Berhampore, Bengal and a sub-station alimpong hill station. The work of organising these stations has been entrusted to the writer.

Relevant matters arising out of the reports of the Tariff Boards and deliberations of the All-India ultural Conference and the results so far obtained through research have been incorporated in this ograph.

The title of the publication suggested by the Director, Board of Scientific and Industrial arch viz., "Silk Production and Weaving in India", includes silk manufacture. To be able to with the present silk manufacturing industry in India presupposes a detailed knowledge of the nt conditions in different parts of the country to which the writer cannot lay a claim. The treat- of the section on weaving has necessarily been attempted in a general way on the basis of data able more to indicate the lines on which development is desirable and necessary than to describe xisting conditions. As a matter of fact this is a fit subject for a separate publication after a proper ical enquiry.

When the writer was entrusted with the preparation of this monograph more as the Editor-in- than the author of it he asked for collaboration of all gentlemen known to be connected with the ndustry all over India including the Indian States and also for help from the Directors of Industries e different provinces and States. But unfortunately there has been hardly any response except one, Rai Sahib M. N. De, who has contributed much information on tasar silk. Therefore the ıration of the monograph fell to the writer wholly. Owing partly to this reason and partly to pre- ›ation with departmental work to which a heavy responsibility in connection with manufacture ırachute components for the military department was added, the preparation has been delayed h beyond the time when it was expected to be completed.

C. C. GHOSH.

RHAMPORE, BENGAL,
5th November, 1944.

PART I.

GENERAL FACTS ABOUT THE SILK INDUSTRY AND ITS REQUIREMENTS.

1. How silk is obtained.

Silk is produced by insects, known commonly as silkworms which spin cocoons with silk filaments exuded through their mouth parts out of silk glands inside their body (Fig. 2).

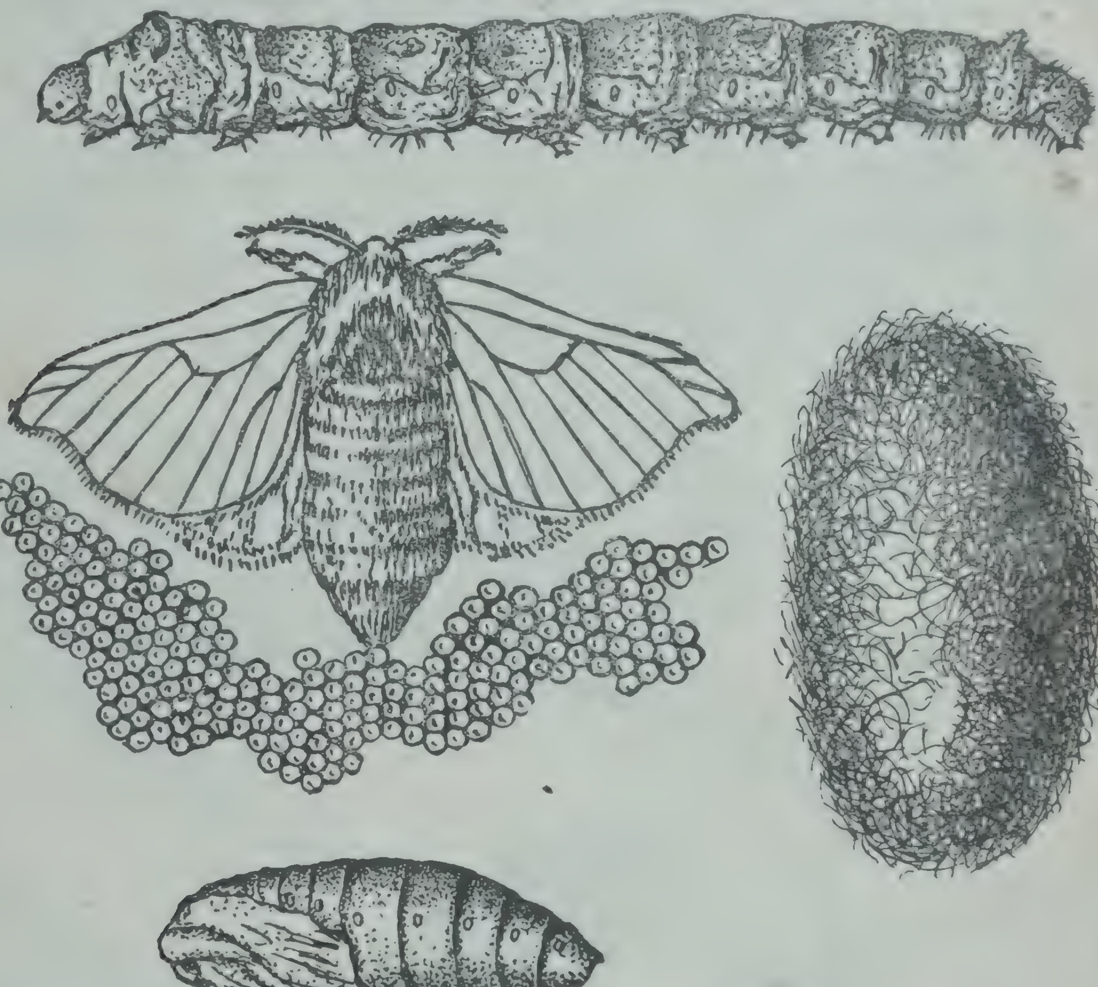


Fig. 1–Life history of the mulberry silkworm. Fullgrown worm, above. Moth laying eggs. Cocoon. Below, pupa taken out of the cocoon.

The silkworm passes through four distinct stages in its life (Fig. 1). The moth lays eggs

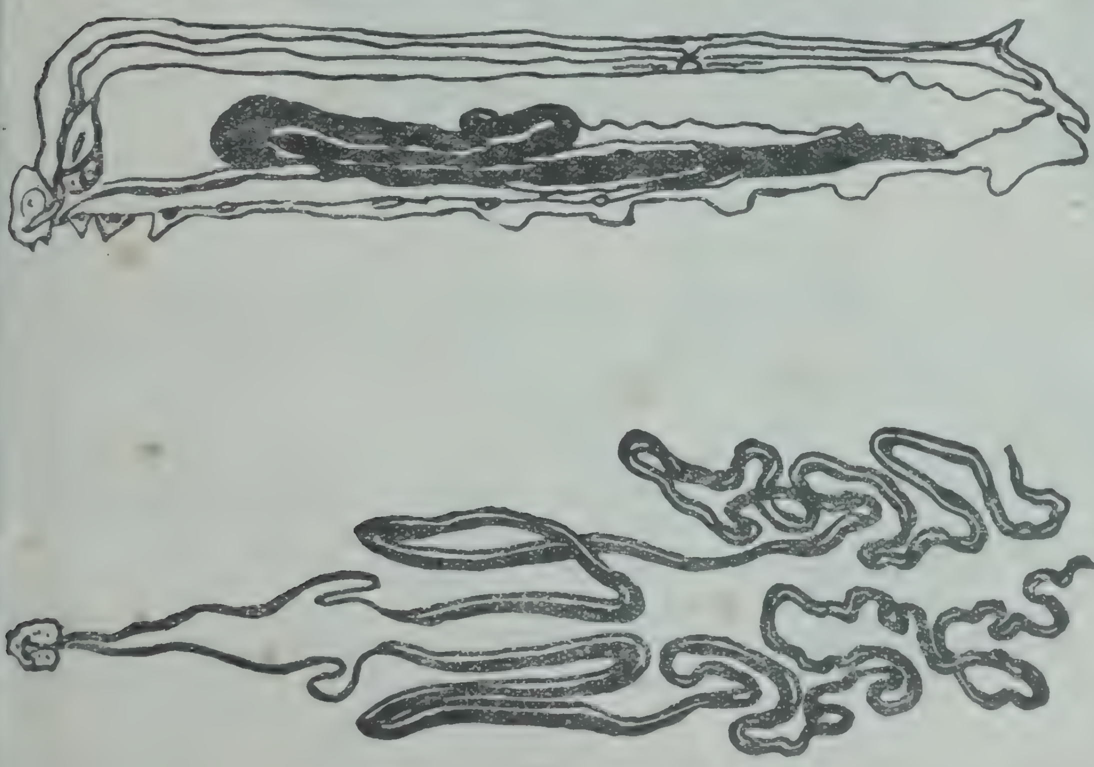


Fig. 2. Silk gland inside the body of the worm in thick black, above. Below, the silk glands are shown separately.

(1st stage) from which tiny worms (2nd stage) hatch, feed on leaves, grow and spin cocoons when full-grown. Inside the cocoon the worm transforms into pupa (3rd stage) and the moth (4th stage) develops from the pupa and lays eggs again. This life history is repeated. The silk thread is obtained by unwinding or as it is called reeling the filaments out of the cocoons.

2. Kinds of silk.

Four different kinds of silk of commercial importance are produced in India.

1. *Silk* :—What is commonly called silk, the well known shiny creamy white fabric filament, is obtained from silkworms, *Bombyx mori* and its varieties (Fig. 1) which feed on mulberry leaves. These worms are completely domesticated and have to be fed and reared indoors. Silk obtained from their cocoons is known as *Resham*, *Pat* or *Garad* in different parts of India. The silk producing areas in India are Mysore with the adjoining Kollegal Taluk in Madras Presidency, Bengal and Kashmir with Jammu. A little silk is also produced in Assam and the Punjab.

2. *Tasar Silk* :—*Tasar*, also spelt as Tussah, is copperish coloured silk obtained from worms (*Antherea mylitta*, Fig. 3) feeding on leaves of *Sal* (*Shorea Robusta*), *asan* (*Terminalia tomentosa*), *arjun* (*Terminalia arjuna*), *baer* or *kul* (*Zizyphus jujuba*) and about thirteen other forest trees.

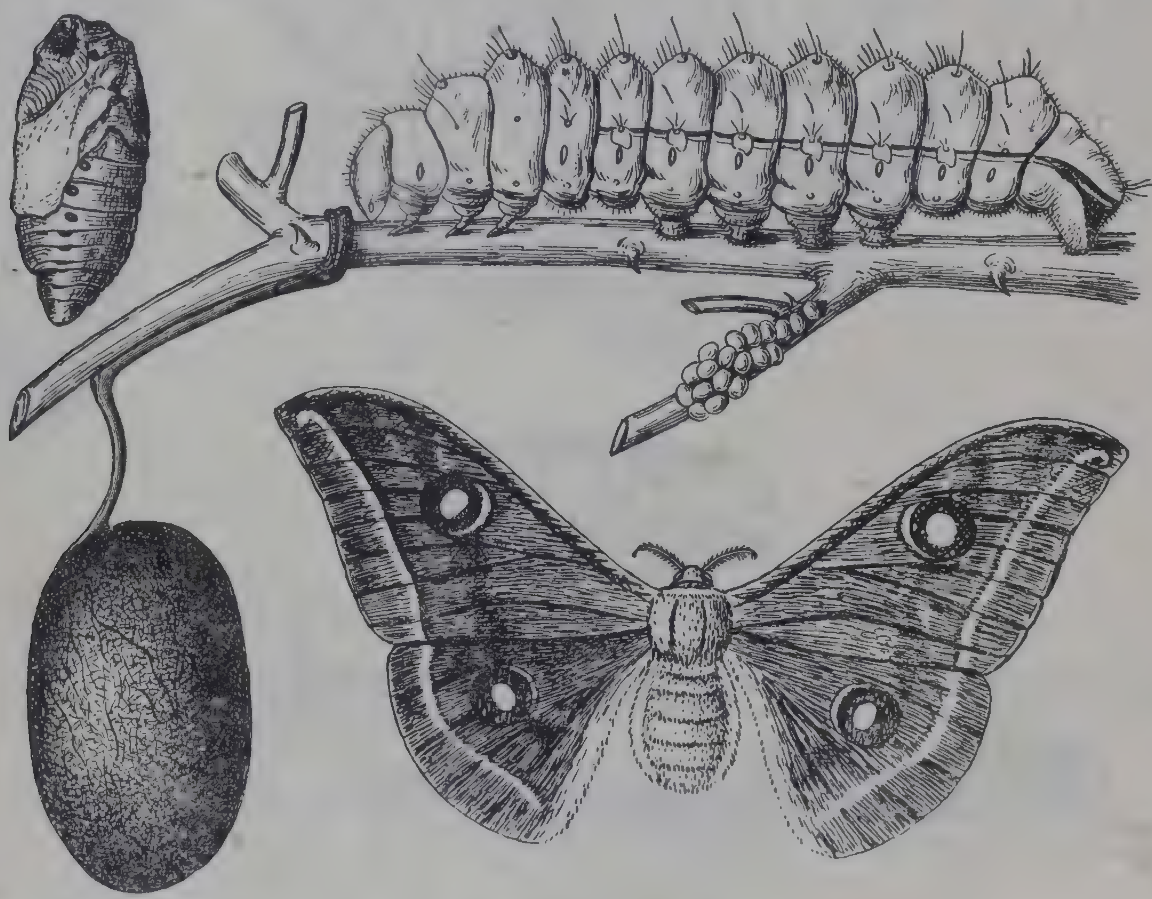


FIG. 3.—Life history of the Tasar worm. Grown up worm on a twig and cluster of eggs on the same. Cocoon fastened to the twig. Pupa taken out of the cocoon. Moth.

The worms are wild in nature and have to be left in the open on the trees where they feed at will and form cocoons which are then collected. Tasar worms are reared by the aboriginal tribes in the Chotanagpur area in Behar and the districts adjoining and surrounding this area and falling in the administrative jurisdictions of Bengal, Orissa and the Central Provinces.

3. *Muga Silk* :—*Muga*, a golden coloured silk allied to *tasar*, is obtained from worms (*Antherea assama*, Fig. 4) which feed on leaves of *sum* (*Machilus odoratissima*) and *hualu* (*Tetranthera monopetala*) and being wild in nature have to be reared in the same way as *tasar* worms.

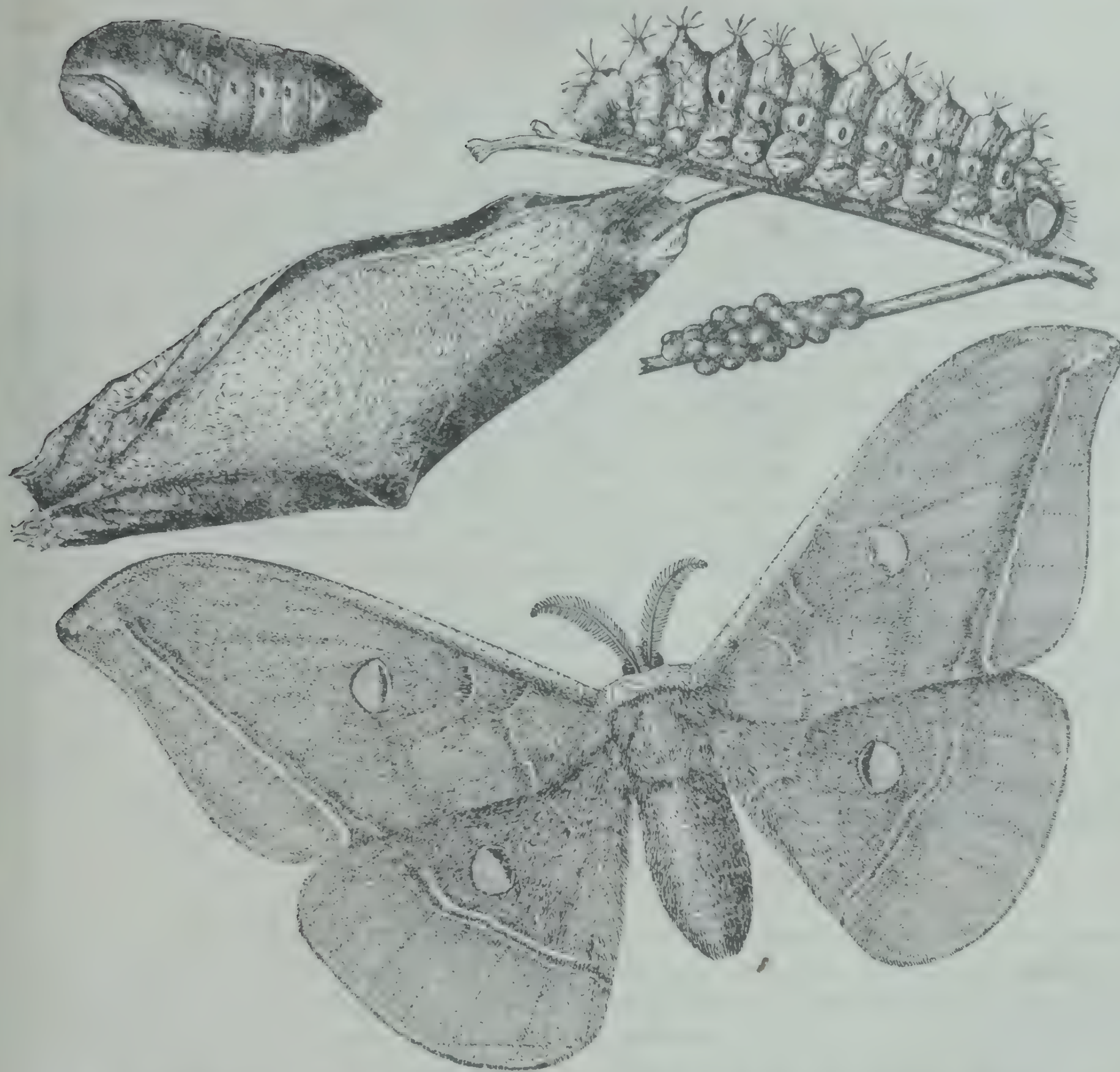


FIG. 4.—Life history of the Muga worm. Grown up worm and a cluster of eggs on a twig. Cocoon formed inside fold of leaf. Pupa taken out of cocoon. Moth.

4. *Eri Silk*:—*Eri*, a creamy white stuff but much less shiny than silk, is obtained from worms (*Attacus ricini*, Fig. 5) which are fed generally on castor leaves and being completely domesticated have to be reared indoors. The word *eri* is derived from the Sanskrit name of the food plant, *Eranda* changed to *Erandi*, *Endi* or *Eri*. Eri worms are reared in Assam and a few of the eastern districts of Bengal.

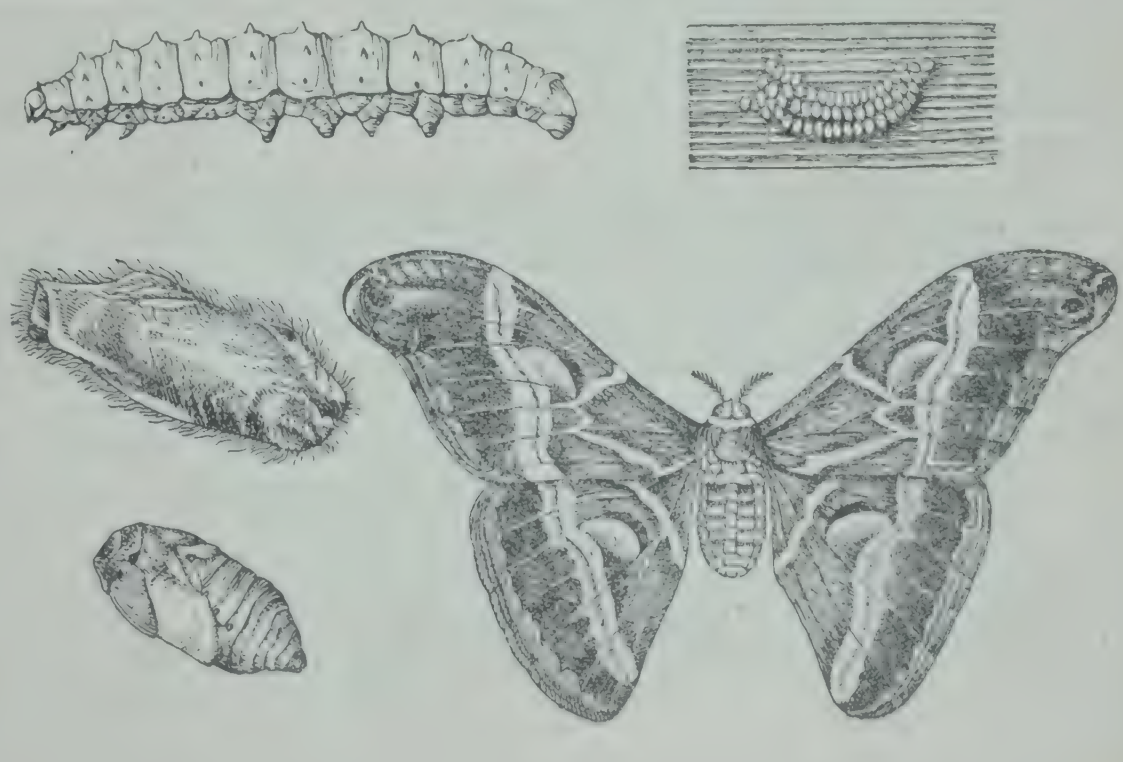


FIG. 5.—Life history of the Eri worm. Above, a cluster of eggs and grown up worm. On the left, a cocoon and pupa taken out of the cocoon. Moth.

3. Differences between the different kinds of silk.

The product of the mulberry feeding worm is the most important and is what is generally understood by the word silk, the others being specifically described as *tasar* silk, *muga* silk or *eri* silk. There are other differences.

Mulberry or castor can be grown and silk and *eri* silk can be produced as much as desired and anywhere provided climatic conditions prove suitable. That is not the case with *tasar* and *muga* silks whose production has limits imposed by the nature of the food plants which are mostly forest trees hardly possible to be grown anywhere on a large scale like mulberry or castor, by the wild nature of the worms themselves not admitting of the control, care and protection against enemies possible in the case of the domesticated worms and also by human and climatic factors. Rearing of tasar and muga worms therefore is limited in particular areas as indicated above. The production of two other allied silks viz., Chinese *tasar*, a brown silk from worms (*Antherea pernyi*) feeding on oak leaves and Japanese *muga*, a light green silk produced by worms (*Antherea yamamai*) also feeding on oak leaves, is similarly confined in certain parts of China and Japan. Continuous unbroken filaments are capable of being reeled out of silk, tasar and muga cocoons, which are therefore classed as reelable. Eri cocoons cannot be reeled but have to be carded and spun more or less like cotton and wool. Eri silk fetches a much lower price than the other silks and its production is also limited in extent being carried out as a small cottage industry. Although attempts had been and are still made to introduce and establish eri rearing in other parts of India they have not so far met with success.

Silk is capable of being developed through scientific efforts and organisation in a way and on a scale not possible in the case of *tasar*, *muga* or *eri*. Detailed information about these latter silks is given in the parts dealing with them.

4. Sericulture.

Sericulture commonly denotes the rearing of mulberry feeding silkworms and is an important industry capable of being carried out anywhere and in any country for at least a part of the year. Economic, religious, social and climatic factors however have been responsible for allowing development of this industry only in certain countries. Sericulture proper forms the first stage of the silk industry consisting of cultivation of mulberry and rearing of the worms and ending with the disposal of the cocoons. The first factor for sericultural success is climate suitable for the worms which can live, grow and form cocoons in a temperature between about 60° and 85° F the best temperature being 70°-75° F with about a similar percentage of humidity. The climate being suitable the industry is suitable as a subsidiary one for peasant families who grow mulberry along with other crops, carry out rearing of the worms mostly with the spare time labour of the family members and sell the cocoons as soon as formed. Rearing on a large scale by paid labour is not successful. The classic case is failure of such an attempt by Lister Company near Dehra Dun. Sericulture is not taken up in highly industrialised countries where people find more remunerative occupation in mills, factories etc., and is carried on in countries with a poor peasantry.

Sericulture is known to be carried on in Japan including Korea and Formosa, China, Indo-china, Thailand (Siam), India, Iraq, Iran (Persia), Palestine, Egypt, Syria, Turkey, Samarkhand and Taskent in Russia, Cyprus, Greece, Albania, Macedonia, Bulgaria, Czechoslovakia, Jugoslavia, Rumania, Hungary, Poland, Italy, France, Spain, Algeria, Morocco, Madagascar, Mexico and Brazil. Some of the countries mentioned are noted for heat in the hot weather. Worms there are reared in spring following the cold weather. Japan alone accounts for the major portion of the world's production of raw silk and individual output of the majority of the other countries is small as will appear from the following figures compiled and published in Japan.

Share of the production of the raw silk in different countries as indicated by exports :—

	1922 %	1934 %		1922 %	1934 %
Japan ..	51·9	82·3	France ..	0·4	0·1
China ..	37·8	11·0	Spain ..	0·2	0·1
Italy ..	7·9	4·9	Turkey, Syria, etc. ..	1·6	1·6
			India, Burma, Siam & Indo-China	0·2	·0

In 1934 India produced about 25,00,000 lbs. of raw silk but had no share in the export trade. The figures for China are based on those of exports.

Being an industry in the hands of the cultivator class, sericulture cannot flourish without State help and its progress and stage of development in any country have been directly proportionate to the help it has received from the State. Progress is dependent on research, experiment and organisation. Sericulture in Japan which is a wonder of the world has been the result of elaborate and extensive arrangement for research and experiment for improvement of mulberry and its cultivation and of worms and cocoons in experimental stations in every district, in central research stations and in Universities, combined with arrangements for sericultural education in numerous schools and colleges, country-wide organisation for production and supply of disease free silkworm eggs (seed) under Government supervision, study of markets for sericultural products all over the world and organisation and regulation of trading facilities, laws being enacted where necessary. Although Japan is progressing fast industrially her Government spares no expense in the interest of sericulture which benefits the rural population in a way no other industry can. (See Appendix I.)

5. Reeling and raw silk.

Reeling is the second stage of the silk industry. The unbroken filaments of the cocoons are unwound or as it is called reeled into thread known as raw silk or net silk which is used in manufacturing silk goods. For this purpose the cocoons are boiled in a basin until the gum holding

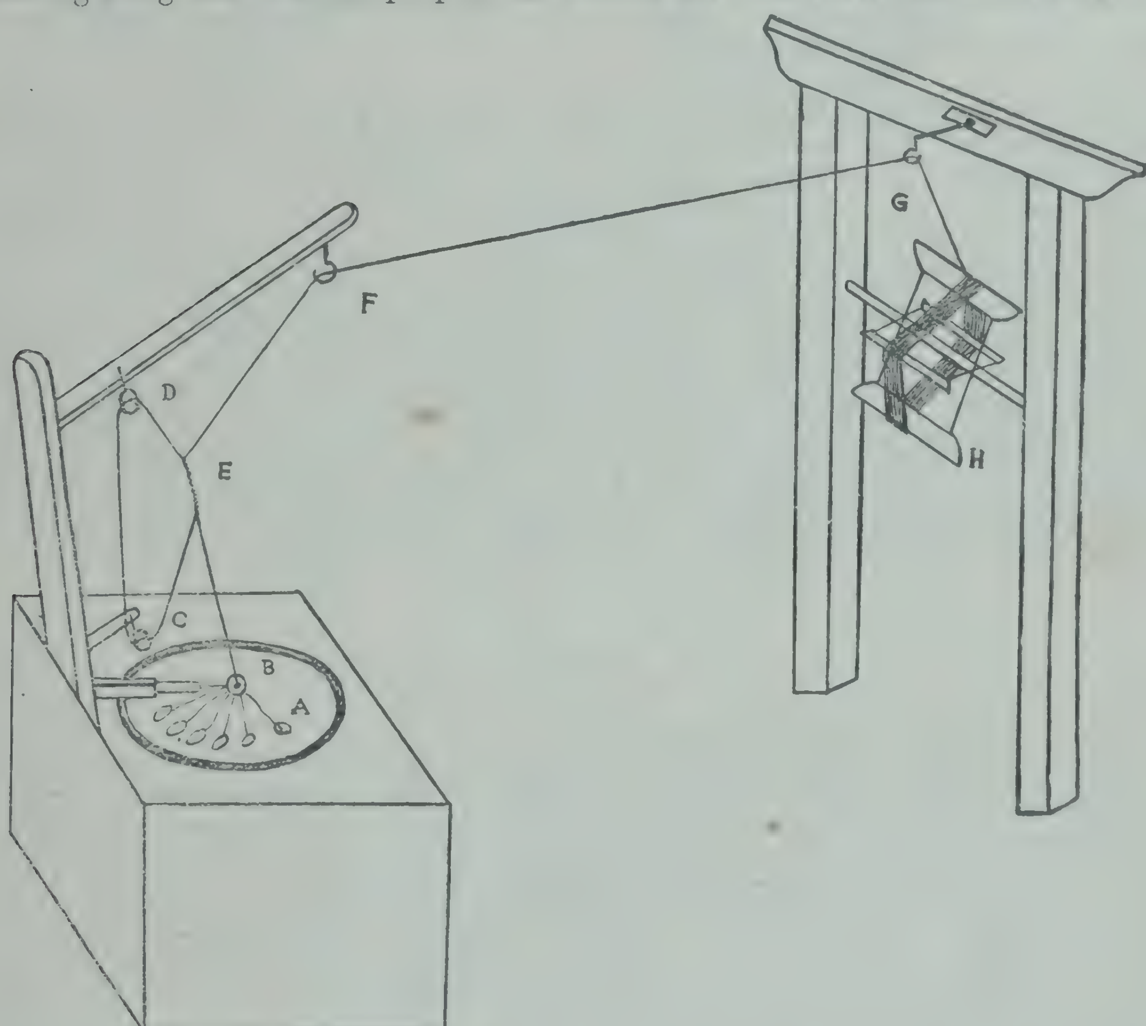


FIG. 6.—How silk thread i.e. raw silk is reeled out of cocoons. Cocoons, A, are boiled in hot water in basin, B. Filaments of several cocoons are passed together through the eye of the reeling button to make up the thread which goes over pulley D and then over pulley C and then is wound over itself many times at E (croisure) and is then passed over hooks F and G to reel H which is kept turning and thus winding the thread on itself.

the filaments tightly together is softened and the filaments thus loosened of several cocoons are passed together to form a thread (Fig. 6). The number of filaments vary directly with the thickness of the thread desired. The adhering gum of the filaments on drying as the thread issues out of the basin agglutinates them into a single compact thread. Reeling has to be done with the help of a machine but there must be a reeler (man or woman) at each basin and the cocoons and filaments have to be manipulated with fingers. Reeling can be and is carried out on single basins or with groups of a few basins as domestic concerns. The demand for raw silk however is in large lots and it is also demanded that the lots must be uniform in thickness and quality, which cannot be ensured unless reeling is carried out in a central place under supervision to see that all reelers reel a uniform quality. For this reason reeling to be successful must be a factory industry using suitable machinery and engaging preferably about one to two hundred reelers. Without such factories, commonly called filatures, raw silk cannot be produced which can be expected to come up to recognised grades fit to compete in international markets and to enable high class silk goods being manufactured. Reeling concerns purchase cocoons from the cocoon-growers, stock and reel them and sell the resultant raw silk. An efficient reeling industry is essential for sericulture and in fact forms the pivot of the silk industry, affording market for cocoons on the one hand and supplying the raw material for the manufacturing industry on the other. For economic reasons filatures are established where sericulture exists. Reeling and sericulture go hand in hand and in fact the extent of sericulture in any country is regulated by that of reeling existing in that country. Reeling and sericulture together are known as the " raw-silk industry ". There are two outlets for the products of this industry. One is export of raw silk to countries where no sericulture exists but silk weaving is practised. The other is manufacturing silk goods which have markets at home and abroad.

As silk is not produced in all countries and as on the other hand many countries like England, France and especially U.S.A. have developed large silk manufacturing industries there is a large export market for raw silk. Without export markets sericulture in any country cannot attain to large dimensions comparable to its development in Japan. Japan was responsible for 82·3 per cent of the world's raw silk production in 1934 and out of Japan's total production 82·5 per cent was taken and consumed by U.S.A. which took 97 per cent of it in 1929. The essential conditions in being able to secure export markets for raw silk are (1) quality (2) standardisation and (3) organisation to produce and supply standardised raw silk in bulk. Japan satisfied the first two conditions through research and experiment and successfully organised large scale reeling and means of supplying standardised raw silk in bulk and was thus able to capture the world's market for this commodity. Japanese raw silk is in demand everywhere. About the sixties and seventies of the last century Bengal's raw silk dominated the world's market but was ousted by Japan as Bengal failed to keep pace with improvements. For the same reason silk fabrics from Bengal had to yield place to those from Japan in the world's market.

6. Silk waste.

Raw silk is obtained from the cocoon filaments which can be taken out in unbroken condition. Such filaments exist in the middle layers of the cocoon shell (Fig. 7) and the outer and inner layers have to be separated out in the process of reeling and form what is known as reeling waste. Pierced cocoons from which moths have to be allowed to cut out for securing eggs or cocoons which are damaged by ants or rats cannot be reeled and they also form waste. Loose fluffy silk filaments covering the cocoons and also broken, torn and rejected portions obtained in the process of preparing raw silk for the loom are wastes. The invention of the spinning mill about the middle of the last century enabled all those formerly looked upon as waste to be cleaned and carded and spun into what is known as " spun silk " as distinguished from the raw silk or net silk. Spun silk is now an important textile fibre and its manufacture an important industry capable of being carried out as a factory one. An inferior portion is obtained in the processing of wastes in the spun silk mill which cannot be used in the spun silk but is separately spun into what is known as noil. The spun silk mill is fitted with machinery for spinning noil. The spun silk can utilise any kind of cocoon and has afforded means of utilising wild silk cocoons for which there was no use before.

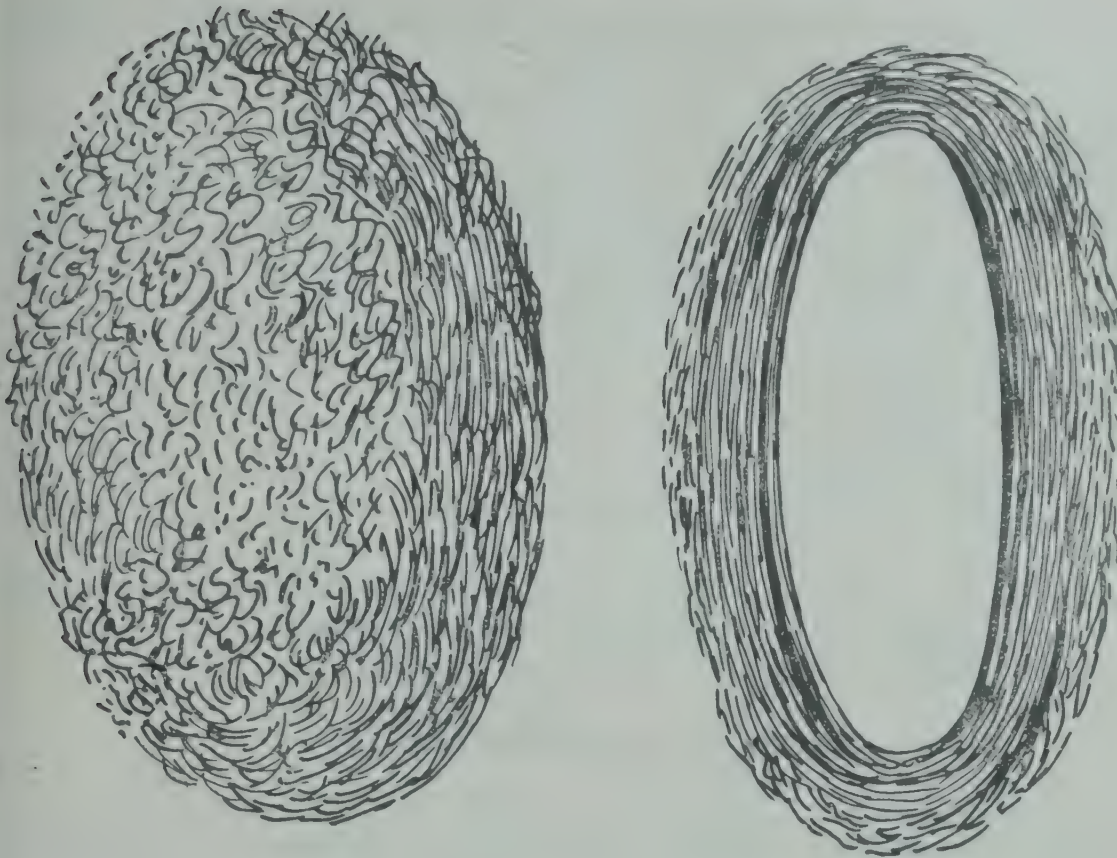


Fig. 7—Cocoon shell and its cross section on right. Fluffy broken filaments on the outside, continuous filament in the middle layer and thin core at the innermost part.

7. Silk weaving or manufacture.

The use of the product of the raw silk industry is in manufacture of woven and knitted fabrics for garments, parachute components, fishing lines, elastic webs, sieves for flour mills, insulation coils for telephones and wireless receivers and tyres for racing cars. For garments silk fabrics are woven in various weaves such as plain, twill, satin, crepe, georgette and velvet and fabrics are dyed, printed, embroidered, figured and ornamentated for use as sarees, jackets, shawls, wrappers, handkerchiefs, ties, gowns, ribbons, tapes, cords and table, umbrella and hat cloths. Knitted goods are produced for use as vests, gloves, socks, stockings, etc. The various silk goods give an idea of the uses to which the silk filament has been put by man for beautifying the body and satisfying taste, vanity and fashion and also of the scope given by silk to the play of imagination and skill for art and beauty. Machinery and methods have been devised to prepare raw silk into yarn suitable for different weaves and for knitting and embroidery. About a hundred trade names are used to describe yarns prepared in different ways and for different purposes. Dyes and methods of dyeing have been invented to dye the yarn and fabric in infinite colours and shades. Gold and silver are worked on the silk filaments to produce gold and silver threads for ornamentation of fabrics. Looms and knitting machines and methods of weaving and knitting have been invented to produce different kinds of fabrics, knitted goods and ribbons. The remarkable Jacquard loom producing any kind of figured design in the fabric in the process of weaving owes its invention to the demand of fanciful utilisation of silk. In the west about three hundred trade names are used to describe broad silk fabrics and about twentyfive names to describe ribbons. In each province in India there are about a hundred names used for describing different kinds of silk goods considered to be specialities of the different areas.

No other textile fibre has aroused or commanded the world's admiration in the same way and to the same extent as silk which has rightly acquired and retained and will as far as evidences go continue to retain its position as the queen of fibres. In the early days of China's monopoly of silk manufacture silk fabrics are recorded to have fetched their own weight of gold in the Roman market.

The severe depression which commenced about 1929 and lasted till about 1938 interfered with the unique trade in raw silk which Japan enjoyed with U.S.A. and led Japan to try and find

out new uses of silk and the following lines were actually evolved (Tariff Board, written evidence, Vol. 1, 1940, p. 1161).

Silk textiles for winter suitings, overcoats and raincoats.
Silk artificial leather.
Silk rugs and blankets.
Silk "Panama hats".
Silk towels.
Silk tissues for airplane wings and parachutes.
Silk alpaca.
Silk typewriter ribbons.
Silk cloth for motor car tyres.
Silk guts for tennis rackets.
Silk tissues for insulators.
Silk textiles for tents.
Silk sea clearing nets and nets for catching fish and birds.
Silk ropes.

The great demand for and an intensive campaign to conserve all kinds of metals have led to manufacture of machinery gears and metal substitutes made of pure silk.

For more detailed information about silk manufacture see part XI.

8. Silk substitutes—Rayon and staple fibre.

Scientists tried to produce an imitation of this costly fibre and succeeded in producing what became well-known as artificial silk. In order to emphasise the difference of this substitute from and to prevent its confusion with silk it is now named rayon and the use of the word "silk" has been prohibited by law in many countries for goods in which rayon is used. Search for cheaper silk substitutes has resulted in other artificial fibres, such as lanital from milk and vinyon and nylon from coal. The evolution of a process of manufacturing rayon cheaply from wood has led to enormously increased use of rayon goods at rapid strides. Staple fibre or spun rayon is produced by spinning rayon filaments cut into small lengths. At present production and use of rayon and staple fibre are about equal in the world. How the use of rayon has increased compared with silk will be evident from the following figures of production in the world in different periods.

Average	Raw silk in million lbs.	Rayon in million lbs.
1909–23	65	19
1924–25	85	85
1931–32	126	508
1934–35	125	835
1937–38	121	1822

Rayon has certainly been responsible for retardation of the rate of increase of silk but has by no means sounded the death knell of silk as is or was wrongly supposed by some. The present war has brought out the importance in present-day warfare of parachutes which are as necessary as guns and ammunitions, and indispensability of silk in the manufacture of parachute components has raised it to the rank of a commodity of vital importance in the life of a nation. Production of silk has got to be increased.

Rayon (artificial silk) and staple fibre are for practical purposes to be considered as two distinct textile fibres. Rayon is produced in lengthy pieces in imitation of raw silk and several strands are used together in manufacturing rayon goods. Staple fibre is produced in imitation of raw cotton and natural wool and spun like cotton and wool to produce a less lustrous thread than rayon and like spun silk. Staple fibre is warmer than rayon and on account of simpler chemical and mechanical processes staple fibre production is cheaper than rayon production. This is why staple fibre although a recent invention at present equals rayon in volume in the world and will soon come to occupy a more dominant position than rayon but will be a competitor of cotton and wool more than silk. In order to form a fair idea of the possibilities of rayon and

staple fibre Japan's efforts in their production give useful data. She has drastically reduced the use of cotton for home consumption and enjoined that in the manufacture of woollen goods at least 30 per cent staple fibre must be used. She is also making vigorous efforts to reduce the cost of production of staple fibre. The forest resources of Japan being limited she is dependent on foreign supply for pulp required in the manufacture of rayon and staple fibre as well as paper. Vigorous researches have enabled pulp being produced from rice husks and straw, reeds, bagasse, mulberry bark, soya bean and sea-weeds. Manufacture of staple fibre and rayon from casein of artificial milk derived from soya beans has been a successful Japanese invention.

How very successful the silk substitutes have been in meeting demands for articles of wear will be evident from the following estimates of consumption of rayon and silk in U.S.A. about 1937 (Tariff Board, written evidence, Vol. 1, 1940, p. 1173).

Comparison of consumption of rayon and silk, year 1937 (*Estimated*).

	000 pounds of yarn.	
Woven goods.—	Rayon.	Silk.
Dresses ..	138,000	6,200
Piece goods (sold by the yard) ..	16,500	2,000
Linings ..	22,000	500
Underwear (also see—knit goods) ..	20,000	5,500
Velvets ..	5,000	1,500
Neckwear fabrics ..	4,000	800
Narrow fabrics, Ribbons, etc. ..	6,000	1,000
Marquisettes ..	2,500	..
Bedspreads ..	4,000	..
Tapestries, Draperies and Upholsteries ..	11,500	100
Knit goods—		
Circular-knit underwear	26,000	..
Hosiery ..	14,000	35,000
Flat-knit underwear and gloves ..	7,000	100
Knit outerwear ..	8,000	300
Other knit goods ..	500	..
All other uses ..	15,000	1,000
Total ..	300,000	54,000

1937, *Yardages of principal rayon and silk woven items* (*Estimated*).

	000 yards of fabric.	
	Rayon	Silk
Dresses ..	700,000	50,000
Underwear ..	125,000	45,000
Piece goods ..	85,000	15,000
Linings ..	90,000	2,500
Total	1,000,000	112,500

9. Origin and spread of the silk industry.

The scanty ancient records which are made use of to trace how the art of utilising the silk-worm's cocoons came to be developed and spread, indicate that the origin is lost in antiquity and China is supposed to be its birth place. The art is ascribed to a Chinese princess, Si Ling Chi (i.e. the enlightened one) about 3000 B.C. The art of rearing the worm and utilising its cocoons is

said to have been kept a secret by China for about 3,000 years. Then a Chinese princess married to a prince of Turkestan carried the art there by smuggling silk worm eggs in her hair. From there two Nestorian Monks smuggled eggs into Byzantium (modern Constantinople) about 550 A.D.. Venetians took the art to Italy about 1204 A.D. during the Crusades and it spread to other countries of Europe from Italy where great improvements were effected in worms, rearing, reeling, processing of the yarns and manufacture but kept secret for a long time. Refugees from Italian civil wars in the 15th century carried the art to southern France round Lyon which became a famous silk manufacturing centre afterwards. Refugees from religious persecution in France after the revocation of the Edict of Nantes carried the art of silk manufacture to England, Holland and Germany. From Europe it spread to U.S.A. In the east too refugees from Chinese civil wars carried the industry to Korea from where captives of war carried it to Japan in the third century B.C. The industry travelled to Cochin-China, Thailand (Siam), Burma and India from China. It is however supposed to have developed independently in India according to another theory which holds the Himalayas to be the birth place of the silkworm which then spread to China and India. Silk is mentioned in ancient religious books of India and was unknown in Egypt and Babylon. The spread and establishment of the industry in other countries mentioned above took place in comparatively recent times.

10. The silk industry in varying state of development.

The silk industry in all its stages is in varying state of development in different countries. It is in the primitive and wholly domestic stage where some mulberry is grown and rearing of worms is done by a family, reeling is done by the rearers themselves on primitive machines and the resultant coarse uneven raw silk is utilised in weaving on hand looms either by rearers themselves or others. Even when the raw silk still produced on hand machines is exported to other countries and has therefore to be reeled on a large scale by a separate class of reelers from cocoons purchased from the rearers the industry has increased in volume but is not much advanced from the primitive state.

For the reasons indicated above sericulture i.e. production of silk is carried out in certain countries but its utilisation is possible anywhere and in fact the demand for silk is universal. Even in India provinces which produce no silk have specialised in and developed admirable silk manufacturing industries. The United States of America have developed a huge silk manufacturing industry which as indicated above consumes the major portion of the world's available silk supply. She consumed 83 per cent of it in 1928 and utilised almost the whole of the resultant silk goods herself only about 1·5 per cent of them being exported to Canada and Mexico. More than 90 per cent of this raw silk came from Japan. On account of the high cost of labour America demands raw silk of high uniform quality easily workable on power machinery and has developed machines and methods of testing the raw silk in order to be sure of its quality before purchase. Japan met these requirements and was thus able to capture this vast market for raw silk. Silk manufacturing industry being developed in other progressive countries like Canada, Australia, etc. also demand high grade raw silk. It will now appear that there is a vast difference between the primitive state of the industry and the developed state as at present in Japan brought about through research, application of science and organisation. The extent of the raw silk industry in any country is proportionate to the quality of its products which is directly dependent on research and organisation. The quality of the products of the manufacturing industry is dependent on that of the raw silk.

In the developed and organised condition the different steps in the different stages of the silk industry are virtually carried on as separate industries leading to specialisation and improvement. Thus the following are known to be carried on as separate industries, viz.,

1. Growing and selling of mulberry grafts.
2. Growing mulberry and selling leaves to silkworm rearers.
3. Rearing and selling silkworm eggs technically known as seed.
4. Rearing young worms upto a certain age and selling them to rearers.
5. Rearing worms and selling the cocoons obtained.
6. Treating and storing cocoons for sale to reeling concerns.
7. Reeling.

8. Throwing i.e. preparing the raw silk into yarns fit for weaving different kinds of fabrics and knitting.
9. Manufacture of gold and silver threads.
10. Weaving of different kinds of fabrics as specialities of different manufacturers in different places and countries.
11. Knitting of different articles by different manufacturers.
12. Dyeing of yarns and fabrics.
13. Printing of fabrics.
14. Finishing of fabrics.
15. Manufacture of spun silk from wastes.

The above indicate the industries directly connected with the production and utilisation of silk. There are other industries or occupations dependent on them, such as :—

1. Making appliances for use in rearing.
2. Working as brokers and selling agents for cocoons, raw silk, waste silk and manufactured goods.
3. Manufacturing machines and appliances for reeling, throwing, weaving, knitting, spinning and finishing.

Some idea may now be formed of the magnitude to which the silk industry can be raised if properly organised. It will also be evident that there is a vast difference between sericulture in primitive unorganised condition and that when developed and organised. As far as development is concerned Japan is at present at the top and as far as known Burma and Assam are among those at the bottom. It is a mistake to consider sericulture in different states of development to be the same. Provided suitable climatic and human factors are there to make sericulture successful there is no limit to its development if proper efforts are made.

It has also to be pointed out that however highly developed the raw silk industry may be its product in its entirety cannot be guaranteed to be of the same uniform high quality. Along with high quality raw silk some inferior grades and some even not superior to the product of the primitive industry will be obtained. This is inherent in the nature of the industry. Even among the same lot of worms some spin cocoons of poor quality. From such and double cocoons high grade raw silk cannot be obtained. It has however to be remembered that silk however poor in quality has a market. Nothing of the products of this industry is wasted.

11. Sericulture is the best subsidiary industry for peasant families. Its other characteristics. Why it declined in Bengal.

We have seen that the raw silk industry involves two stages, first, cocoon production and second, reeling. The first is successful when carried out as subsidiary to the main occupation of peasant families. As rearing is carried out mainly by family labour it is possible to sell cocoons at a price which would be impossible if all labour were to be paid for. The price of raw silk which regulates the price of cocoons is subject to periodical and wide fluctuations. When prices fall and they have fallen very low at times, it is its domestic cottage nature which keeps the rearing industry alive and rearing of cocoons is continued as long as rearers find a ready sale for them and receive some return for their labour. In warm climates like those of the plains of India rearing is possible upto about seven or eight times in the year and fetch in cash as many times to the rearers. When mulberry leaves are available actual rearing does not take more than about a month and cocoons are sold off as soon as formed. There is no agricultural crop which can bring in money so quickly and so many times in the year.

Although rearing is a cottage domestic industry the nature and requirements of the reeling industry demand that cocoons should be produced by each family in large quantities at a time so that reeling concerns may not have to collect small lots from numerous sources. Production of one to two hundred pounds of cocoons at a time by individual families is common and there are rearers in some Bengal districts who produce one to two thousand pounds at a time. It is the close attention of the family which ensures success in large rearings. Rearing is not a difficult work but its technique requires to be learnt practically and it demands care and timely attention to details.

Silkworm rearing being a subsidiary industry of peasant families is subject to several subtle economic factors. When the peasants find an alternative more remunerative occupation through

industrialisation of the area or another more remunerative money crop to grow in place of mulberry, rearing of silkworms tends to diminish. It is the industrially undeveloped country of poor peasants where sericulture is practised. This is why silkworm rearing did not succeed in England, Germany or U.S.A. Continuous prevalence of low prices for raw silk and cocoons have a similar depressing effect and high prices stimulate production.

It will be evident that sericulture or cocoon production cannot properly speaking be described as a "cottage" industry as ordinarily understood by the word cottage except in its small scale primitive state. In order to feed an organised industry worth the name mulberry must be grown and rearing carried out on a large scale. Then again although generally carried out as subsidiary to agricultural work of the family, silkworm rearing can be and is actually carried on as the main occupation of about six thousand rearing families in Bengal at the present time. They are skilful mulberry growers and silkworm rearers and earn sufficient money for their subsistence from this work. Sericulture cannot exist unless there is an assured market for cocoons in the form of reeling factories. Cocoons which are produced in the plains of India, in Bengal, Mysore, Madras, Assam, Bihar, Bombay, Central Provinces or Burma are of a nature which does not admit of their being transported to another province or country to be reeled there. Cocoons produced in southern China, Indo-China, and Siam are also of this nature. Reeling factories must be organised for such cocoons locally. Cocoons produced in other countries, such as Japan, northern China, Persia (Iran), European countries and Kashmir can be transported to other countries and reeled there. Mainly through the efforts of the East India Company, Bengal developed large reeling factories all of which went into the hands of the European firms after the East India Company discontinued this work and they were in a flourishing state in the sixties of the last century. Even as late as 1904 there were 75 filatures employing 9,526 workers according to the Financial and Commercial Statistics of the time. Owing partly to the inferiority of Bengal cocoons and partly to these factories not keeping pace with improvements in machinery and methods and thus being unable to produce and supply raw silk of standardised quality similar or comparable to what Japan supplied, Bengal lost the export market for its raw silk as well as silk fabrics as already indicated. The result was that the reeling factories closed down and simultaneously cocoon rearing and mulberry area decreased as there was no market for cocoons. The European reeling concerns helped many local people to set up reeling factories and purchased and exported the produce of the latter who remained contented with the disposal of their output locally and never got into touch with the export markets, with the consequence that they too had to close down along with the European factories. Sericulture practically disappeared from the districts which dealt with these factories. This was the reason of the rapid decline of sericulture in Bengal. The district (Malda) which had country reeling basins still working was not so badly affected. The raw silk produced on country basins was of poor quality and not acceptable in outside markets. Bengal sericulture was therefore reduced to a moribund condition. Japan through research and experiment kept pace with up-to-date reeling machinery and methods and set up organisations to be able to cater for and retain foreign markets. During the period of severe depression and low prices between 1929 and 1939 the Japan Government purchased and stocked the produce of the reeling factories at a loss of about eight crores of rupees in order to maintain the reeling factories. The sericultural department of Kashmir which is organised mainly to carry out reeling and get cocoons reared by the villagers for the purpose similarly carried on the reeling factories at a loss of several lacs of rupees every year.

The action of the Japan and Kashmir Governments indicates the importance of reeling in the cause of sericulture in any country. Mysore, Madras and Bengal, the principal sericultural areas in British India have had no organised reeling industry which must be developed if sericulture is to flourish and expand in these areas as desired. Unless standardised raw silk of good quality can be produced and supplied in bulk and in large quantities no export market will care for their raw silk. The other outlet for the products of sericulture viz., manufactured goods will be helped by standardisation of raw silk which is necessary for the manufacture of good quality standardised fabrics.

12. Diseases of the silkworm as an important factor in sericulture.

Silkworms are liable to suffer from four principal recognised diseases viz., (i) Pebrine, caused by the attack of an internal protozoal parasite, *Nosema bombycis*, (ii) flacherie, comparable to diarrhoea and cholera of human beings according to its intensity, (iii) grasserie, comparable to

jaundice and (iv) muscardine, caused by a parasitic fungus. Out of them the first one is highly contagious as well as hereditary in the sense that germs present in the body of parents pass on to the offspring. It practically wiped out the sericultural industry of Europe in the middle of the last century and the industry could be revived only with eggs imported from Japan. The famous Louis Pasteur investigated it, found out the causal agent and evolved a method of controlling it by microscopic examination of the body tissue of mother moths after eggs are laid and rejecting the eggs of those having pebrine corpuscles in their body. This is now an essential routine practice in sericulture and exercises sufficient control on this disease when properly adopted and followed and in addition precautions are taken against infection through contagion. Success in sericulture depends on efficient organisation for microscopically examined disease free seed (egg) production and supply. Seed production by unauthorised private persons is prohibited by law in Japan and all seed used in Japan is required to be examined and passed by Government seed examination centres. Other countries where sericulture is organised though not having such strict laws take steps to see that silkworm rearers get examined seed. France and Italy have fairly strict laws. In India, Kashmir has a very good organisation for examination of the eggs she produces locally. Mysore has been organising examination through grainages both Government and aided. Bengal followed a method of production of seed cocoons for general rearers from examined seed and has now been organising production and supply of examined seed in place of seed cocoons, which cannot be guaranteed to be disease free though reared from examined eggs as the seed cocoons may contract disease in the course of rearing. Organisation for production and supply of microscopically examined disease free seed is indispensable if success in sericulture is desired and this organisation must be in Government hands.

13. The race of the worm reared as an important factor in sericulture.

Some silkworms pass through only one cycle of life in spring and remain dormant as eggs which hatch again next spring. Such worms are known as one-brooded or univoltine. There are bi-voltine, trivoltine, tetravoltine and poly or multivoltine or many-brooded races. These last pass through successive cycles without rest and can be reared as many times as desired during the year and in overlapping broods. This difference in the life and habits of the different races seems to have been brought about mainly by the climate of the places where the worms happen to exist. The races occurring in tropical and necessarily hot countries are generally multivoltine ordinarily having cycle after cycle occupying only about six weeks, this period however being lengthened in the cold weather and according to intensity of cold. Their eggs hatch under normal temperature in about a week without special treatment. Univoltine worms reared continuously in warm climate can be turned multivoltine and similarly multivoltine ones tend to be univoltine when reared continuously in cold temperature. Multivoltine worms are reared in southern China, Indo-China, Siam, Burma, Assam, Bengal, Madras, Mysore and other places in the plains of India. The worms reared in Kashmir and the Punjab and all other countries are mostly univoltine. For uniform hatching univoltine eggs require to be subjected to a cold temperature of about 32° to 40°F for a period of about four months just before hatching and then incubated at about 75°F. China and Japan rear bivoltine worms also but to a small extent. Countries which rear univoltine worms enjoy an advantage over those rearing multivoltine ones in that univoltine cocoons are better than multivoltine ones in silk content and length of reelable filament. Multivoltine cocoons of India have about 1 to 1½ grains of silk and yield a reelable filament about 150 to 350 yards long. Univoltine cocoons generally have about 3 grains or more of silk and yield a filament about 800 to 1 000 or even 1,200 yards long. Univoltine worms do not thrive and therefore cannot be reared in warm countries. Such countries can carry out rearing practically throughout the year and require multivoltine races. Bengal however has a degenerate univoltine race, Baropolu, which is reared in spring but is hardly better than the local multivoltine Nistari and Chotopolu. It is reared with difficulty on a small scale and is now being replaced by hybrid Nistid and Nismo.

Application of science where properly made through research and experiment has circumvented the disadvantages inherent in both univoltine and multivoltine worms and the actual achievements and improvements effected and successfully adopted in practice and described below indicate the lines on which further progress seems possible.

(A) *Artificial hatching of eggs* :—Through application of cold and use of hydrochloric acid univoltine eggs are made to hatch artificially any time and Japan in place of one crop of cocoons

actually rears three crops in spring, summer and autumn. A method of using electricity for the same purpose has been evolved in that country but has not come into general practice like the first method. (For details see Silk Industry of Japan, pp. 59-60).

(B). *First generation (i.e. F_1) cross-breed worms*:—Researches and experiments in Japan proved that the offspring of first generation crosses between different univoltine races produced cocoons with larger silk content and longer filaments than the pure races themselves. At present the major part of rearing, 80 to 90·4 per cent, in Japan is done with F_1 crosses between Japanese, Chinese and Italian races. For this purpose some varieties have been selected out of about one thousand existing in Japan. Suitable Chinese and Italian varieties have been similarly selected. The selected varieties are maintained in pure condition in research and experiment stations, sufficient quantities of seed cocoons of these races are reared under supervision and crossing is supervised and the resultant eggs are made available to general rearers. No seed cocoons are kept from these F_1 hybrids and crossing is done every time between pure races and the resultant F_1 seed is reared. Figure 8 shows the cocoons of the pure races and those of F_1 crosses generally reared in Japan.

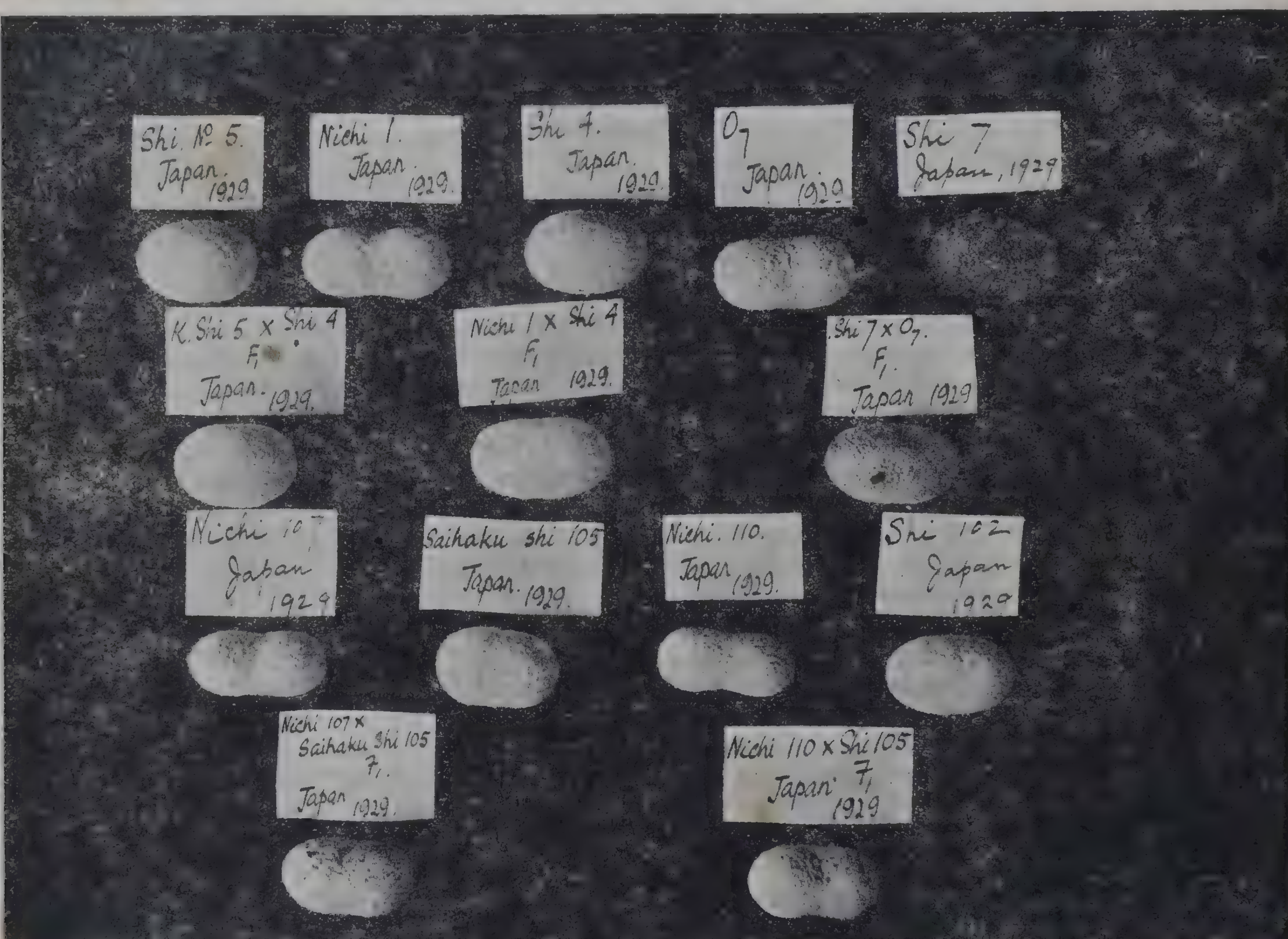


FIG. 8—Cocoons generally reared in Japan.

Top row—Cocoons of univoltine parent races, shi means Chinese, nichi Japanese and 0 Italian. 07 and shi 7 are yellow and the rest are white.

Second row—First generation, i.e. F_1 cocoons of crosses between the parent races and these are reared by the general rearers. Shi 7×07 is yellow and the others are white.

Third row—Cocoons of bi-voltine parent races, all white.

Bottom row—First generation i.e. F_1 cocoons of crosses between parent bi-voltine races, both white. These are reared by the general rearers.

The Mysore Department of Sericulture has successfully adopted a system of first generation cross between univoltine males and the local multivoltine Mysore race female. For this purpose univoltine Japanese races have been imported and turned multivoltine locally and maintained and reared under supervision at the same time as the Mysore race with which crossing is intended. When moths emerge crossing is effected and the F_1 eggs are made available to the rearers. The system of supervised aided grainages set up here has rendered F_1 cross egg production and supply possible. The F_1 worms are more resistant to diseases and produce better cocoons than the indigenous multivoltine Mysore worms.

In Bengal too F_1 crosses between Japanese and indigenous Nistari and Chotopolu as well as introduced hybrid, Nistid, have produced better cocoons than the parents. But it has not been possible to adopt them yet on a large scale for want of an organisation like the aided grainages of Mysore. Establishment of Nistid and Nismo races described below has however brought about a vast improvement.

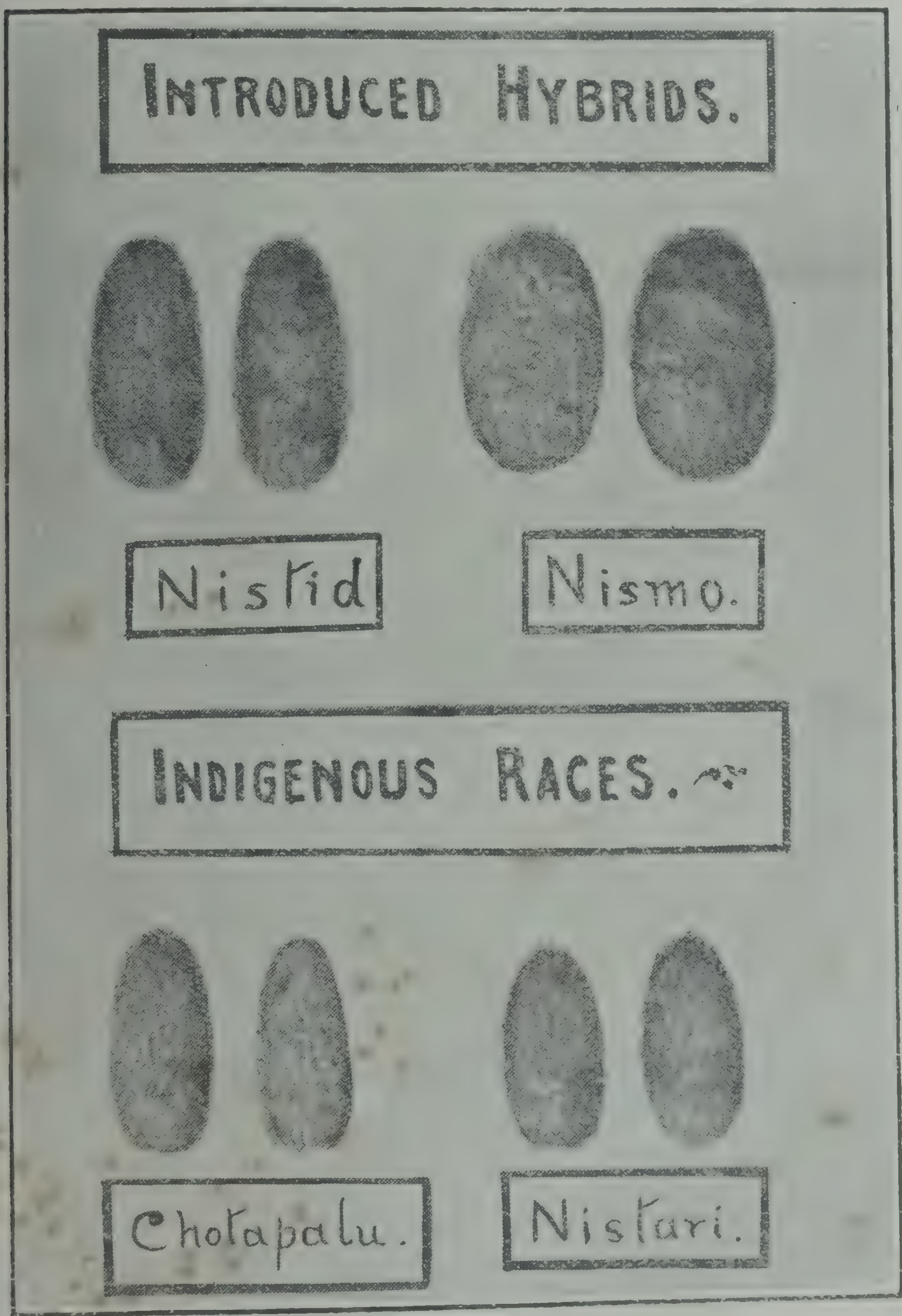


FIG. 9—Yellow cocoons of the indigenous multivoltine races, Nistari and Chotopolu, of Bengal and introduced multivoltine fixed hybrids, Nistid and Nismo.

(C) *Fixed multivoltine hybrids* :—Through hybridisation between superior univoltine and inferior multivoltine races of worms and then selection in the course of the successive generations of these hybrids and elimination of undesirable qualities some multivoltine types can be fixed with desirable qualities and producing cocoons with much larger silk content and longer filament than the cocoons of degenerate multivoltine worms. The existing multivoltine worms in Bengal, Assam and Burma are probably the poorest of silk worms in the whole world. The Mysore worms are slightly better. Through hybridisation between a superior Italian and an inferior multivoltine race the writer succeeded in evolving several types of fixed multivoltine hybrids in Burma producing cocoons with properties about midway between those of the cocoons of the parent races. It took nearly six years to fix them, eliminate undesirable qualities and make them fit to be reared in the same way as the existing multivoltines. These hybrids originally produced yellow cocoons. But in the course of later generations threw out Mysore type slightly greenish white as well as pure white cocoons which afterwards bred true. When the writer came to Bengal

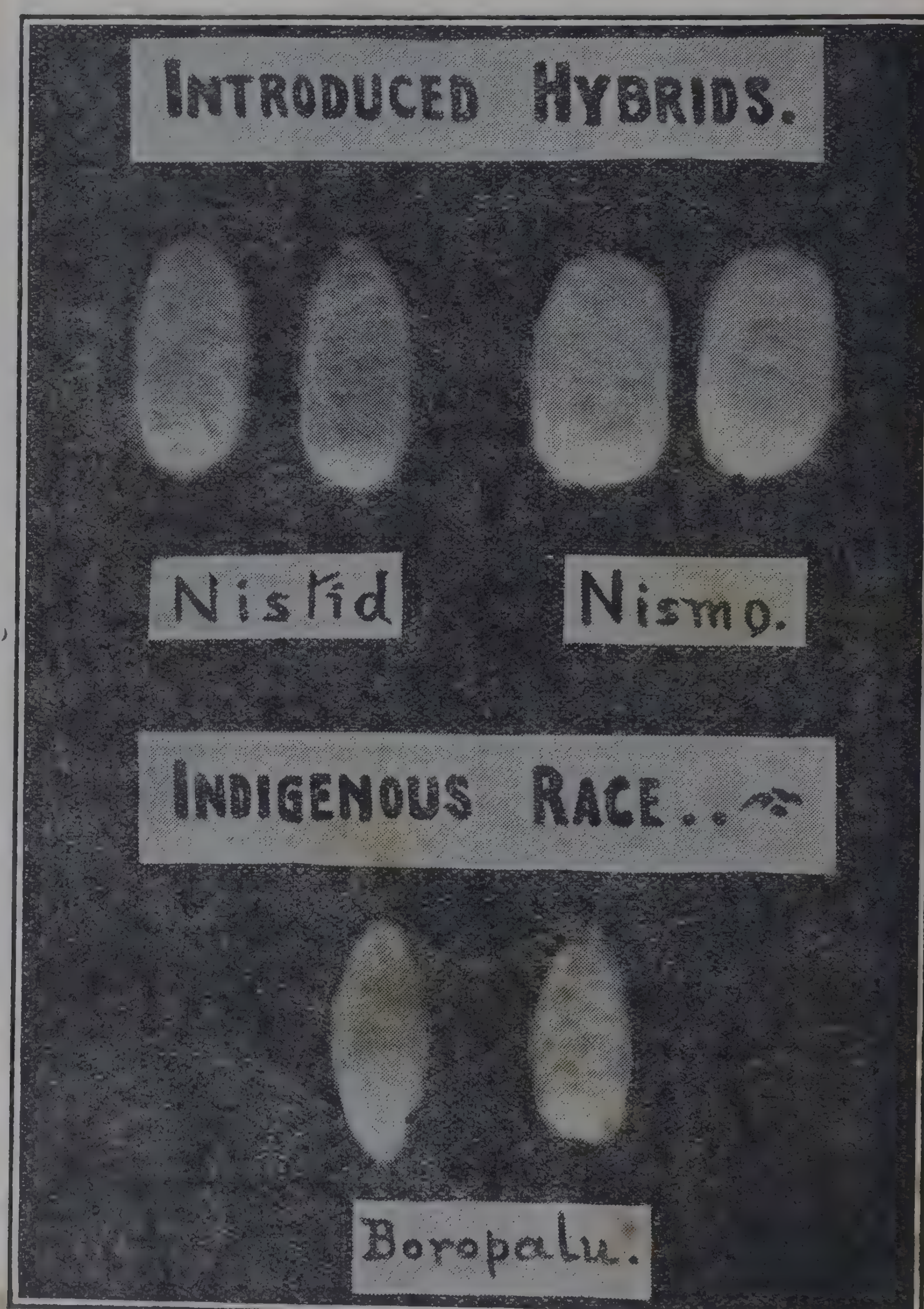


FIG. 10—White cocoons of the univoltine Bengal race, Boropolu and of the introduced fixed multivoltine hybrids, Nistid and Nismo.

in 1936 he introduced these hybrids there and two named, Nistid and Nismo, have since been successfully established there. These cocoons contain about 2 to 3 grains of silk according to season and quality of food and filaments about 500 to 800 yards long. Figures 9 and 10 show the cocoons of the indigenous Bengal Nistari, Chotopolu and Boropolu races and these improved introduced hybrids. These hybrids have given Bengal rearers both yellow and white cocoons of much better type which can be reared throughout the year. Previously white cocoons used to be obtained only from the univoltine Boropolu in spring. Nismo was obtained through an additional dose of Italian blood on the Nistid and then through selection.

Figures 8, 9 and 10 give an idea of different types of cocoons produced by different races of worms. The univoltine cocoons (Fig. 8) are compact and stiff and without fluff on the outside. The multivoltine cocoons according to degree of degeneration tend to be soft and to have a loose fluffy covering from which a continuous filament cannot be obtained and which goes into waste.

(D) *Necessity of evolving suitable univoltine races in India* :—The silk industry of Kashmir and Jammu was revived with seed (eggs) of univoltine races and imported from France and such seed continued to be imported every year, hibernated locally and reared. At present Kashmir produces a large quantity of seed locally though Jammu continued to use imported seed only. The present war has stopped the foreign supply and it has been found that the locally produced seed maintained in the country is not giving satisfactory results. It is also found in Mysore that the foreign races maintained in the country for production of F_1 cross seed are proving unsatisfactory. Both these places are feeling the necessity of importing fresh foreign univoltine races. The remedy lies in evolving suitable univoltine races in India and maintaining them, so that (1) such races may be available for rearing in Kashmir, Jammu, the Punjab and other possible areas such as Kalimpong in Bengal and Khasi hills in Assam. (2) They may be utilised in producing F_1 crosses where desired, and (3) they may be used in evolving fixed multivoltine hybrids like Nistid and Nismo and further improving them.

14. Mulberry i.e. the food of the worm as an important factor in sericulture.

Mulberry is the foundation of the sericultural industry and on the whole accounts for nearly sixty per cent of the cost of cocoon production. There are numerous varieties of mulberry and they differ in their food value for the worm which feeds on this leaf only and nothing else. The quality of the cocoon depends on sufficiency and the quality of the leaf the worm eats. With bad leaf or insufficient supply of food the worm may not thrive and will probably form a poor flimsy cocoon or may get diseased and die and form no cocoon at all. For securing good cocoons it is essential to arrange for good and sufficient food with high nutritive value. In Japan about 385 distinct varieties of mulberry are known to exist and out of them about nine have been selected out and are cultivated for the worms, some being suitable for the colder districts, some for districts with a milder climate and still others for districts with a severe winter. Some are early, some late and some midway between the early and late ones. Varieties are selected and grown according to convenience of rearing. Also as a result of long continued experiments it has been found that grafts develop a better root system than seedlings, layerings or cuttings. Therefore grafting has been adopted universally. Varieties have also been selected out whose seedlings are suitable for use as stocks for grafts.

In India hardly any attention has been paid to this important aspect of sericulture. Foreign varieties of mulberry have been introduced in the past in all sericultural areas viz., Kashmir, Mysore and Bengal but hardly any one of them has been adopted. There have been no attempts at separating out the mulberry varieties existing and imported botanically and no investigations to find out their relative food value for the worm or suitability for the soil and the climate or response to treatment and manures.

Mulberry can be grown from seeds, cuttings or grafts and as low bush or small, medium or large trees. Different areas at present grow it in different forms. Kashmir and Jammu began sericulture with the trees they found growing in these areas. The sericultural departments of these places are now growing fresh trees either from seedlings or grafts. Grafts or seedlings three years old and about six feet high produced in nurseries are distributed. Leaves are plucked from the trees or small twigs or branches bearing leaves are pruned for feeding the worms which are reared here only once in the spring. The Punjab is trying to foster sericulture on trees grown on canal banks and other suitable places. Bengal grows mulberry as a low bush in fields from

cuttings. The bushes are pruned down at the base usually level with the ground four to seven times in the year in different places, that is, as many times as cocoons are reared. After pruning fresh shoots grow to be pruned down again in the succeeding rearing. Recently grafting has been introduced there by the writer and a system of growing dwarf grafted trees as a field crop called "high bush" developed which is illustrated and described in the body of this bulletin (see Figs. 21-23). The yield of leaves of high bushes compares well with that of the old bush but the quality of the former is much better. The Bengal Sericulture Department has also arranged for getting trees from grafts which are grown in nurseries and made available to rearers when about six feet high. Bonus is being paid for 5,000 trees every year for seven years in the first instance at the rate of two annas per tree planted, one anna per tree surviving in the third and one anna similarly in the fifth year. There is however a large demand from rearers already for one year old grafts to be grown as trees without bonus.

Mysore and Madras grow mulberry as bush in fields from cuttings. Here the practice is to pluck leaves from the bushes which are pruned down level with the ground only once in the year. The leaves growing on mature stems are better in quality than those of the Bengal form of bush. Mulberry is a plant which improves on pruning. For this reason yield of leaves is much greater in Bengal than in Mysore form but as already indicated at the expense of quality. In a small area in Mysore bushes are grown under irrigation and pruned down for every rearing as in Bengal. In some places in Bengal for instance Bankura and Midnapur the practice of feeding worms with plucked trees is in vogue. The Mysore Sericulture Department has adopted a system of getting trees grown on payment of bonus at the rate of 2 annas per tree. For this purpose the department grows seedlings in nurseries and makes one year old seedlings available to the rearers.

In Assam mulberry is grown from cuttings generally as bush which is however allowed to grow and leaves are plucked for feeding worms.

The method followed in Bengal and a part of Mysore of pruning down the bush in every rearing is the worst in that the leaves are of poor quality and frequently they are pruned and used before the stems and leaves mature. The method of plucking leaves and using them without pruning the stems is better as the leaves grow on mature stem. The system followed in Kashmir and Jammu of using leaves of mature trees is the best. Without such leaves the rearing of univoltine worms would not have been successful. The indigenous multivoltine worms Nistari and Chotopolu as well as the univoltine Boropolu of Bengal have adapted themselves to the poor food. Superior worms do not thrive on such food. The improved hybrids from Burma, Nistid and Nismo, when introduced into Bengal did not at first do well on this food and suffered especially from grasserie disease. They have however now adapted themselves to it but their cocoons have become smaller. They however do well when fed on good food.

As regards cost of production of leaves bushes are the most expensive. They require good cultivation and manuring. The high bush is less and trees are the least expensive. When once established the high bush will last for 20 to 30 years and trees for about fifty to a hundred years requiring only pruning in time. In the multivoltine rearing areas trees alone will not yield leaves for so many rearings. They have to be combined with high bushes. Varieties have to be selected out after proper trial which will yield sufficiently and leaves of high nutritive value. The method of cultivation and manuring have also to be worked out. As a general rule leaves on mature stems should be aimed at. Cost of production should be as low as possible. As already indicated cost of leaf is the main item of expenditure in cocoon production. In the interest of sericulture this cost should be attempted to be kept low through larger yield of high quality leaves possible from high yielding varieties with high nutritive value and made to yield heavily through proper method of cultivation and treatment.

15. Climate as an important factor in sericulture.

Silkworms under rearing are liable to be affected by the bad quality and insufficient quantities of food given to them, by unclean conditions under which they are kept in the rearing house, by lack of sufficient fresh air, by very high and low temperatures and by very high and low percentage of humidity in the atmosphere. Silkworms breathe through nine pairs of spiracles or breathing holes opening on the sides of the body and the inhaled air circulates throughout the internal tissues of the body through ramifications of the air tubes which spread to and reach all parts of the body. The number of worms under rearing is necessarily large and they are more

or less crowded together. If they are kept in a stuffy room without proper ventilation the air gets vitiated and affects their health. Overcrowding and want of ventilation and cleanliness in the rearing house have injurious effects and have been dealt with in connection with diseases (section 47). Different provinces and States frequently enquire about the suitability or otherwise of their areas for sericulture. As this is primarily dependent on temperature and humidity this matter is discussed in detail here.

Temperature :—Temperature has a direct bearing on the worm. A suitable degree of warmth enables the body organs to function well and the worm feeds and grows well. A very low temperature retards bodily functions and the worm eats and grows slowly. Similarly a very high temperature quickens the functions and hurries the worm through the stages thus giving it hardly any opportunity to grow healthily. Temperature suitable for the worm in all its stages should be in the neighbourhood of 75° F and may range from 70° to 80 F. The worm may stand a temperature below 70° F upto 65° F or above 80° F upto 85° F. When the temperatures are below or above these ranges the worm is bound to suffer unless arrangement can be made to keep it warm or cool as necessary. Both in very low or very high temperatures eggs will not hatch properly, worms will not feed, grow and spin cocoons properly and moths will not lay eggs properly. Between these ranges again generally speaking univoltine worms do better in the lower ones between 65° F and 80° F and multivoltine ones between 70° F and 85° F.

Humidity :—Humidity too has a direct effect on the worm, more or less in the same way as temperature and is suitable when between 70 and 75 per cent and may fluctuate between 60 and 85 per cent. Humidity is indicated by the difference in the dry and wet bulb thermometer readings and this difference is suitable when about 6 degrees and may fluctuate between about 3 and 9 degrees. It is difficult for the worm when the moisture in the air is so high as to cause this difference to be less than about 3 degrees or when the air is so dry as to cause it to go beyond about 9 degrees. When the humidity is too low i.e., when the air is too dry leaves dry up quickly and add to the troubles of the worm which does not grow well and spin only small cocoons and eggs do not hatch well. Too humid atmosphere weakens the worm which may grow fat but becomes more prone to diseases and forms cocoons of loose fluffy texture. Cocoons spun while it rains become difficult to reel or may not reel at all for fine reeling.

Generally speaking if both high temperature and high humidity prevail it is bad for the worms and more harmful than high temperature combined with low humidity or low temperature combined with high humidity. Concrete examples of the places where rearing is done at present will give a clear idea of the influence of temperature and humidity.

Kashmir :—The monthly normals of temperature records at Srinagar, 5,204 feet above sea level are as follows :—

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Max. °F.	40·7	43·6	55·1	65·9	75·8	83·0	85·7	84·9	79·6	70·4	60·5	47·4
Min. °F.	27·1	28·7	37·2	44·9	51·8	58·3	64·4	63·7	54·2	41·1	31·7	27·6
Rainfall in inches	2·76	2·73	3·63	3·79	2·27	1·48	2·32	2·33	1·60	1·09	0·43	1·44

Hibernated eggs are distributed in the early part of May, incubated in the rearers' houses at a temperature of about 70° to 75°, fire being used in the houses for the purpose and the worms which hatch spin cocoons by about the second and third week of June. July, August and part of September seem to be suitable months. But as univoltine worms are reared and as all leaves are used up in spring rearing a second crop is never attempted but is possible with provision of leaves and artificial hatching of eggs.

As regards altitude the rearing villages are situated in three clearly distinguished tracts viz., *kandi* tracts between 5,600 and 6,000 ft. above sea level, *maidani* tracts between 5,300 and 5,600 ft. and *salabi* tracts about 5,200 ft. above the sea level in the level part of Kashmir valley. As regards behaviour of the worms, success in rearing and quality of cocoons produced even with the same race of worms the *kandi* tract is the best, *maidani* and *salabi* tracts coming next in order.

Jammu :—Monthly normals of temperature and rainfall records at Jammu city (about 1,000 feet above sea level) are as follows :—

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Max. °F.	66·1	68·8	75·3	88·7	99·3	100·4	94·6	92·1	92·9	88·0	76·2	66·7
Min. °F.	45·5	52·1	55·8	66·9	76·9	80·7	77·8	76·3	73·9	65·4	54·7	47·5
Rainfall in inches	2·38	2·36	2·65	1·73	0·79	3·58	13·35	14·39	3·10	0·07	0·20	0·89

The rearing villages are situated at altitudes varying from 1,000 ft. to 5,000 ft. above sea level. In the lower and hotter altitudes seed is distributed in February and rearing completed by March. In the colder altitudes eggs are distributed in April and rearing done about May.

Mysore (including Kollegal in Madras) :—The altitude is about 2,300 to 3,000 ft. above sea level and the temperature is between 70° and 85° F for the greater part of the year and not rising beyond 95°F even in March, April and May. Rearing is therefore possible to be carried out throughout the year but hot weather cocoons are poorer than those of the other seasons. Rearing is carried out practically throughout the year with overlapping crops of worms. Owing to the absence of the parasitic fly rearing is carried out even in open verandahs of the rearers' houses.

Bengal:—The rearing areas in the plains of Bengal are situated below about 150 ft. altitude and suffer more from heat than from cold. For the protection of the worms against the inclemencies of the weather under such circumstances the most suitable rearing house is built with thick mud walls and thick straw thatch and having covered but unenclosed verandahs all round. The verandahs help to prevent rapid fluctuation of temperature in the room. With sprinkling of water on the floor in hot weather and having a little fire in the cold months the conditions in such a house can be further improved for the silk worm.

The following statement shows for a year from July 1941 to June 1942 the rainfall records of the meteorological station of Berhampore in Murshidadad District (altitude 67, latitude 24° and longitude 28°) and also (I) temperature and humidity of the locality from the records of the meteorological station, (II) temperature and humidity records of a mud-walled and thatched rearing house at the sericultural farm at this place, and (III) similar records in another similar house in the same farm but treated with water and fire as necessary in the hot and cold months.

	July '41	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.'42	Feb.	Mar.	April	May	June
Rainfall in inches	16·93	15·41	6·38	8·93	1·61	..	0·10	0·73	0·52	3·08	2·44	5·89
Temperature												
I. Max. °F.	96	96	95	95	89	84	82	93	102	104	111	105
Min. °F.	74	76	75	67	56	51	50	49	60	65	70	74
II. Max. °F.	88	88	86	86	78	70	70	78	87	89	93	93
Min. °F.	77	79	76	72	65	63	63	66	74	80	83	82
III. Max. °F.	87	86	86	85	79	73	74	75	84	86	92	92
Min. °F.	82	82	78	72	69	67	65	66	72	76	82	82
Humidity.												
I. Max. %	98	98	98	95	94	94	97	97	98	92	93	93
Min. %	63	67	67	54	54	47	32	20	12	23	20	37
II. Max. %	95	95	95	90	88	83	83	83	80	75	90	90
Min. %	64	65	64	61	53	50	56	41	40	43	49	64
III. Max. %	96	92	96	96	90	89	89	89	86	90	91	91
Min. %	83	87	87	72	73	70	72	66	56	73	73	76

Rearing is carried out practically throughout the year in such houses under climatic conditions which are certainly adverse and apparently unsuitable.

It will be evident that the rigours of the climate can be minimised to a great extent with a suitable rearing house and with fire or water where necessary. In cold countries, for example in Japan, a pit is maintained in the centre of the floor of the rearing house for a slow fire to raise the temperature when necessary with arrangements for ventilation for the hot air to escape drawing in fresh air from outside.

For judging the suitability or otherwise of a place or time for rearing of silkworms daily records of minimum and maximum temperatures and the difference between dry and wet-bulb temperatures should be consulted. Mean monthly temperatures hardly give a correct idea. High temperatures say 100° F and above prevailing for three days may cause disaster among the worms under rearing.

Lefroy mentions the following limiting conditions under which sericulture becomes impossible (Report on an inquiry into the Silk Industry in India, Vol.III, p. 61).

(1) Mean maximum temperature for the month 100° F or over.
(2) Mean minimum temperature 50° F and under.
(3) Mean wet bulb temperature 75° F or over.

This hardly conveys any idea of the climatic conditions suitable or unsuitable for silkworms. The rearing house used has also to be taken into consideration in addition to records of temperature and humidity as described above. The rainfall record should also be considered in order to arrive at a method of mulberry cultivation. Although the rigours of climate can be minimised in the rearing house the multivoltine worms reared throughout the year cannot wholly escape the effects of the climate prevailing in the different seasons. Thus the same race of the worm produces less eggs and produces cocoons with less silk content in the dry hot months or very cold months. The periods taken by eggs to hatch, by the worm to feed, grow and mature and by the pupa to develop into and cut out as moth, vary according to season. The results of general observation in this respect in Bengal are given below to illustrate the points but they should not be taken to be strictly applicable in all cases. Such considerations do not arise in the case of univoltine worms which are reared only once in the spring.

In Bengal and places like Bengal rearing multivoltine worms, continuous rain occurring in the course of a rearing may cause grasserie disease in the worms if fed with wet leaves and if it rains continuously when the worms spin cocoons, these cocoons do not reel well and are termed *gazla*. If however there be showers off and on and the worms get warm rainless periods to spin cocoons hardly any harm is done. When the bush mulberry is grown without irrigation as in Bengal and it is pruned down to the base at each rearing the hot weather and even spring present a difficulty about mulberry. In rearing the prewinter (Agrahayani) crop of cocoons practically all mulberry is used up. Then the growth is slow in winter. Therefore there is always a scarcity of leaves in spring although the season for rearing is good. In order to take advantage of both the good seasons for rearing it is advisable to make separate provision for mulberry to be used in the two seasons. For prewinter rearing both bush and trees do well. But for spring rearing it is necessary to have high bush and trees and treat them so that they may bear abundant leaves for spring rearing. In the hot weather too if there be drought and no rain the growth of bush mulberry is very poor and slow and the leaves are not only small but contain hardly sufficient moisture. Worms fed with such leaves do not get sufficient nourishment and therefore form poor flimsy cocoons. High bush and trees which send their roots deep and are therefore hardly affected by drought are very necessary.

As far as climatic influences are concerned the best places for rearing multivoltine worms are those which have a fairly distributed rainfall throughout the year allowing of growth of mulberry, have temperatures varying between about 65° F and 85° F and have relative humidity varying between about 60% to 85%. The rainfall may vary from about 50 to 70 inches. The suitability of any area may be judged according as it approximates to these conditions. For univoltine worms the temperature is better between about 70° and 80° F and they should be reared on leaves of high bush, medium trees or trees.

16. The present state of silk production in India.

The three areas in India where this industry exists on an appreciable scale are Mysore with the adjacent Taluk of Kollegal in Madras, Bengal and Kashmir with Jammu. The industry in Kashmir and Jammu is well organised and is worked and managed by the State. The sericultural departments of these two places with a separate director for each look after and renew mulberry trees which are preserved as State property, import and also produce seed (silk worm egg) locally under modern hygienic conditions, hibernate the seed, distribute hibernated seed free of charge to the village rearers, look to incubation of the seed in the rearers' houses, supervise rearing, allow the rearers to take and utilise leaves from mulberry trees free of charge, receive cocoons from the rearers who are paid for their labour in rearing in the shape of a price fixed for the cocoons reared, treat and dry the cocoons, store the dried cocoons, reel the cocoons in large well-equipped filatures and sell the resultant raw silk and silk waste. The production of raw silk in these two places amounts to about 200,000 lb. per year. The quality although fairly good suffers from the absence of a conditioning house and there is room for improvement of the grades. With univoltine cocoons and the reeling equipment, very high class raw silk is possible to be manufactured here, if efforts are made with the help of a conditioning house.

Bengal:—The glory of Bengal's industry (both raw silk and silk manufacture) is in the past. How the industry contracted here with the closing of the European filature concerns between the seventies of the last and early part of the present century has already been indicated above (Section 11). The severe depression which commenced about 1929 causing precipitate fall in prices of raw silk and involving in loss the few reeling concerns still carrying on, caused further contraction of reeling and cocoon production. The area under mulberry decreased from about 18,000 acres in 1915-16 to about 9,000 acres in 1939 which marked the lowest ebb in the Bengal industry. There has since been an increase in mulberry area to about 12,000 acres and further gradual increase is expected every year. Reeling became confined to country basins producing raw silk of a poor quality which lost the market even in the other provinces of India in competition with Kashmir's products and imported raw silk of better quality from China and Japan. Since about 1937 however serious efforts are being made and measures have been or are being taken at the writer's suggestion to resuscitate the industry. As indicated above better yielding hybrid races of worms have been introduced and established, better methods of mulberry cultivation have been introduced and are being adopted by the rearers, grown mulberry grafts are being raised and distributed free of cost to be grown into trees, a reeling institute has been started, efficient reeling machines have been devised and are being manufactured locally and are being adopted by the reeling concerns in place of the old charkhas as well as by large organised filatures newly started, and a raw silk Conditioning House, the first of its kind in India, has been established and is helping production of graded and internationally acceptable qualities of raw silk. As a result a large demand for raw silk has arisen both from other provinces of India and foreign countries. The Conditioning House proved to be of immense help in the manufacture of parachute components and its services are requisitioned from all over India. There is now a proposal to establish Conditioning Houses in other areas. As it is essential to increase silk production His Majesty's Government has been helping with money the establishment of filatures in Bengal which will automatically stimulate cocoon production. Private capitalists are also coming forward and establishing filatures. The present production of raw silk in Bengal is about 500,000 lbs. and is expected to increase in the near future. It is necessary to mention here that the new machinery and methods of reeling adopted in Bengal are for producing re-reeled silk. The raw silk is first reeled on small reels and then re-reeled into standard hanks. In Kashmir, Jammu, Mysore and Madras the raw silk is at once reeled into large hanks. As re-reeled raw silk eliminates a lot of defects and improves in the process of re-reeling Japan which had originally adopted the French and Italian method of reeling directly into standard hanks changed the machinery and adopted re-reeling throughout the country.

Bengal arranged for research on systematic lines since 1937-38 for improvement of mulberry and cocoons and control of diseases of worms. The Calcutta University and the Bose Institute afforded Laboratory and other facilities and a private donor gave land and a building for mulberry research station at Dum-Dum. The heads of the zoological (Prof. H. K. Mookerji), botanical (Prof. S. P. Agharkar), and physical chemistry (Prof. J. N. Mookerjee) departments and the Professor of Bacteriology (Rai Bahadur Dr. Gopal Chandra Chatterji) of the University College

of Science were good enough to help the research officers with technical advice where necessary. The scheme administratively approved by the Government of Bengal of having a proper Sericultural Research and Training Institute where these research officers could carry on their work and which at the same time could arrange for training of sericultural staff and teachers, has been held up on account of war conditions. The Government of India has however taken up this question and has sanctioned a Central Sericultural Research Station to be stationed at Berhampore with a sub-station at Kalimpong and the writer has been entrusted with the duty of organising the stations as Officer-in-Charge. These stations are intended for the improvement of the sericultural industry throughout India.

The existing arrangement for sericultural education in Bengal is very meagre. Two classes are maintained for practical training of village rearers' sons in improved mulberry cultivation and rearing extending over a year in two sericultural farms and small grants are made to village primary schools to arrange for instruction being given on sericulture to the pupils. A scheme for starting sericultural classes in village schools is under consideration.

Mysore :—Mysore's is at present the largest raw silk industry in India but here too there had been until about three years ago no organised filature. Except one small Government concern practically all the reeling was done on country basins. The Mysore plateau where rearing is done has a natural advantage in that being about 2,300 ft. to 3,000 ft. above sea level it enjoys a milder climate than the plains. About 1929-30 there was about 53,000 acres under mulberry which the depression was instrumental in bringing down to 25,000 acres. There has been appreciable rise in this acreage within the last three years. The present production of raw silk is estimated at about 800,000 lb. which is expected to increase in the near future.

As already indicated the Mysore sericultural department has brought about improvement in cocoons by effecting and introducing F_1 crosses, has been growing and distributing one year old seedlings to be grown as trees on payment of bonus, has been producing first generation cross eggs in Government and aided grainages and supplying them to rearers, and has carried out some researches on refrigeration of silkworm seed and seed cocoons the results of which have been adopted in the production of F_1 cross seed. The Mysore Government had previously established a power filature and about three years ago contributed 10% of the share capital and granted concessions of land and water in starting the first private filature. This paved the way for other filatures. His Majesty's Government is helping with monetary contributions establishment of filatures on the same lines as in Bengal. The Mysore Government has also helped establishment of a spun silk mill at Channapatna, the first of its kind in India, by contributing 15% of the share capital, lending the services of an experienced officer and giving other concessions.

The sericultural department arranges for training of staff and affords facilities to others coming from other places in India. Arrangements have been made for practical sericultural instruction in mulberry cultivation and rearing in a few vernacular schools in villages.

Madras :—Sericulture is carried on in Kollegal Taluk adjoining the Mysore District and really forming a part of the Mysore plateau. The same method of mulberry cultivation is followed, the same race of worm is reared and use of similar F_1 crosses has been adopted as in Mysore. There is one private filature assisted by Government. But the major portion of reeling is done on country basins. The production of raw silk is estimated at about one to one-and-a-half lac lb. His Majesty's Government is helping with monetary help establishment of filatures as in Bengal and Mysore.

Assam :—The Assam Sericulture Department is trying to foster all the three kinds of silk viz. mulberry, *muga* and *eri*. The production of silk is small in volume and there is no organised reeling. The industry is in primitive domestic state.

Bihar :—There is very little mulberry silk production here and the Bihar Government is trying to spread *eri*. Rearing of *tasar* worms is most important in this province and the Government is trying to improve *tasar* worms.

The Punjab :—The industry is small in this province. The department is trying to expand it. As already indicated mulberry trees are grown on canal banks and other places and one-brooded races of worms are reared in spring with imported eggs. Recently seed production is being attempted locally. The department maintains a small reeling and throwing plant at Amritsar.

The Central Provinces :—*Tasar* rearing is of some importance here. The Department of Industries has just taken up trial with mulberry silk.

Orissa :—*Tasar* rearing is of some importance in the areas near Chhotanagpur.

Bombay :—The Department of Industries has been trying to establish mulberry silkworm rearing. There had been attempts at *eri* rearing but without much success.

Baroda :—Attempts were made to establish *eri* but with hardly any success.

Rajputana :—Some States are trying to establish silkworm rearing.

17. Essentials of a successful silk industry.

I. For sericulture proper i.e. upto the production of cocoons :—

(1) Good mulberry with leaves with high nutritive value and grown in a manner which will ensure supply of abundant leaves at minimum cost.
(2) Good races of worms suitable for the locality.
(3) Production of disease-free seed of suitable races of worms and supply to the rearers.
(4) Skilful rearers as otherwise mismanagement of the worms may nullify the effect of the first three items.
(5) Continuous research for (1) & (2) and efficient organisation for (3) and propaganda and facilities of training for (4).

II. For the reeling industry i.e. manufacture of raw silk out of the cocoons :—

(1) Filatures with efficient machinery and following up-to-date methods of reeling and able to produce recognised grades of raw silk in large quantities.
(2) Raw silk conditioning house (a) to help the filatures in producing recognised grades of raw silk and (b) to test and give certificates of weight and quality of the raw silk in order to facilitate transactions. Without this certificate no export is possible.
(3) Organisation for supply and marketing of standardised raw silk in bulk.

III. For the silk manufacturing industry i.e. weaving and knitting of fabrics.

(1) Efficient processing (throwing) machinery to prepare the yarn for weaving, knitting, etc.
(2) Efficient looms for weaving fabrics and similarly efficient machinery for knitting, etc.
(3) Up-to-date designing, dyeing and printing.
(4) Finishing.
(5) Cloth conditioning i.e. inspection (a) to bring about uniformity and standardisation of fabrics and (b) to issue certificates and stamp fabrics to signify standard. Export of fabrics is not possible without such conditioning.
(6) Organisation for production, supply and marketing of standardised fabrics in bulk.

18. The future of silk production i.e. raw silk industry and its requirements.

The first point to be emphasised in this connection is that there need be no apprehension as to the future of silk. Its indispensability in the manufacture of parachutes has increased its importance immensely. India is the only country in the British Empire producing silk in appreciable quantities and it can bring about a vast increase in production with efforts on scientific lines. The Tariff Board found that the raw silk consumed in India normally was about 40,00,000 lb. out of which about 15,00,000 lb. was produced in India about 1939 and the balance imported. In addition to this about 11,00,000 lb. prepared yarn, 270,00,000 yds. silk goods and 86,00,000 yds. mixed silk goods were imported every year. To this the practically unlimited requirements for parachutes have to be added. Therefore there is vast scope for sericulture. There are climates which allow of rearing of both kinds of worms viz. superior univoltine races producing cocoons of similar quality as in northern China, Japan, Italy, France and other mid-eastern countries and also multivoltine races producing cocoons practically throughout the year. Kashmir and Jammu have developed an admirable sericultural industry with univoltine races at altitudes between about 5,000 to 5,500 ft. The lower hills and submontane regions all along the Himalayas from the North-Western Frontier province to Assam have regions where rearing of univoltine cocoons can be developed. Two such regions with which the writer is acquainted are the Khasi Hills in Assam and the Kalimpong sub-division of the Darjeeling district

in Bengal. This latter is especially suited in that the whole of it is dotted with homesteads carrying on agriculture. It is necessary to grow mulberry trees and introduce rearing. Many places in the plains of India can rear multivoltine cocoons at least for a part of the year.

What is required for establishing, developing and carrying on sericulture is indicated below :

(1) An organisation to get suitable form of mulberry grown. In new areas mulberry cuttings and grafts have to be arranged for and supplied to the prospective rearers. In areas where sericulture is existing, bush mulberry requires renovation every ten years or so, the high bush about twenty and trees about fifty years. Therefore nurseries require to be maintained. In bush form cuttings can be taken and utilised for new plantation from existing bush. But in the interest of improvement of sericulture and cheapening cost of production the bush form is better replaced by high bush and trees.

(2) An organisation to produce disease-free eggs of suitable races of worms and supply them to the rearers. Microscopic examination of the eggs must be under Government control and supervision. The Kashmir and Jammu departments either import examined eggs from Europe or produce eggs themselves for supply to the rearers. The Mysore department has developed a good system of aided grainages suitable for multivoltine races which purchase seed cocoons reared by rearers under supervision, get the moths to lay eggs, examine the moths and sell disease-free eggs to rearers. In the beginning Government sericultural farms can carry out this grainage work and supply disease-free eggs to rearers. When seed production and supply are under Government supervision uniformity of the product i.e. raw sillk can be ensured by arranging for eggs of a uniform race of the worm. Cocoons of different races of worm cause disuniformity in the raw silk while the demand is for a uniform raw silk.

(3) For establishing sericulture in any new area sericultural farms are essential to serve as practical demonstration centres for mulberry cultivation and rearing and to produce and supply disease-free eggs to rearers. In the case of an existing industry too especially with multivoltine worms such farms or stations are essential to maintain stocks of worms in healthy condition and to carry out experiments with new forms and types of mulberry and new worms. Rearers of silkworms get money from the sale of cocoons reared. If the price of a pound of cocoons be taken as eight or ten annas, a very fair price, it is evident that unless a rearer produces about a hundred pounds at a time the remuneration is not sufficiently encouraging unless he gets at least Rs. 50/- as a result of his trouble in growing mulberry and then rearing the worms for about three weeks to a month during which time the members of his family render some help. It is necessary to see to it that rearing is commenced on some scale by the rearers in a new place.

(4) Organisation to purchase cocoons reared by the rearers and reel them. In new areas this organisation is best started at the same time as rearing and carried out with up-to-date machinery and in up-to-date methods so as to produce raw silk conforming to recognised grades. It is a mistake to allow reeling to be commenced in slovenly methods producing bad raw silk. Cocoons can be reeled in primitive methods. It becomes difficult to change these methods afterwards. Modern machinery and methods have been arrived at after a good deal of trial and it is wise to adopt them at once. Graded silk cannot be produced without the help of a conditioning house. It is not necessary to have a conditioning house at the beginning but help of one must be taken. In the case of an established industry it is essential to see that filatures are maintained and they must work in co-operation with a conditioning house.

(5) The requirements of the country itself cannot maintain an extensive sericultural industry and it is essential to seek and cater for foreign markets. Good graded raw silk is in great demand. For this purpose an organisation is necessary which can study demands, apprise producers of the requirements, put producers in touch with markets and above all ensure delivery in time and in bulk and according to specifications.

(6) Research is essential to study and improve mulberry and methods of its cultivation, to improve races of worms so as to have better and still better cocoons and to study and evolve conditions and methods which enable the worm to live healthily in order to be able to produce good cocoons. Improvement of reeling and raw silk is possible only with improved cocoons. Research in this respect in India is emphasised for another reason. Kashmir, Jammu and the Punjab rear imported univoltine worms. The war has stopped the supply of eggs from Europe and cocoon crops raised from locally maintained worms are proving unsatisfactory. Japan having prohibited exports of eggs Mysore is feeling difficulty in securing univoltine races for

production of F_1 cross eggs. Bengal has been lucky in securing the new improved fixed hybrids. For further improvement pure univoltine strains are necessary. New areas suitable for univoltine worms can be developed if only suitable univoltine races can be secured. It is difficult to get pure strains from other countries. There are suitable cold regions in India and it is necessary to organise research so as to establish and maintain pure strains as has been done by Japan. This is a subject for continuous research and only research can solve it. A properly organised sericultural research institute is an essential necessity.

Research is similarly necessary to improve reeling machinery and methods and also weaving machinery and methods.

(7) Sericulture is a highly technical science and in order to ensure success it is essentially necessary to arrange for training of staff and spread of knowledge of proper methods of rearing and mulberry cultivation among the rearers through education and propaganda.

19. Operations in sericulture i.e. production of cocoons.

Sericulture comprises—(1) mulberry cultivation, (2) arrangement for production and supply of seed (eggs), (3) rearing of the worms until they spin cocoons, and (4) treatment and disposal of the cocoons reared. Each of these subjects is dealt with below in detail serially.

PART II.

MULBERRY.

20. Conditions under which mulberry can be grown.

MULBERRY is a hardy plant and grows in soils which can support any plant life. But it cannot stand water-logging and does not flourish in shade or in soils which are very sandy. It responds to the varying qualities of the soil, good cultivation and preparation of the soil and manure. In poor soil and with indifferent cultivation the bush mulberry in Bengal yields only about 4,000 lbs. plucked leaves per acre in a year but as much as 24,000 lbs. when grown in good soil and properly cultivated. If the soil is not cleared of other roots and grasses and not properly cultivated mulberry can hardly spread its roots and grow, as will be evident from the difference in growth of the cuttings in Fig. 11. Mulberry should be grown in open places which are well drained and where it can get sufficient sun and air. It can be grown as bush, high bush, medium tree or large tree.

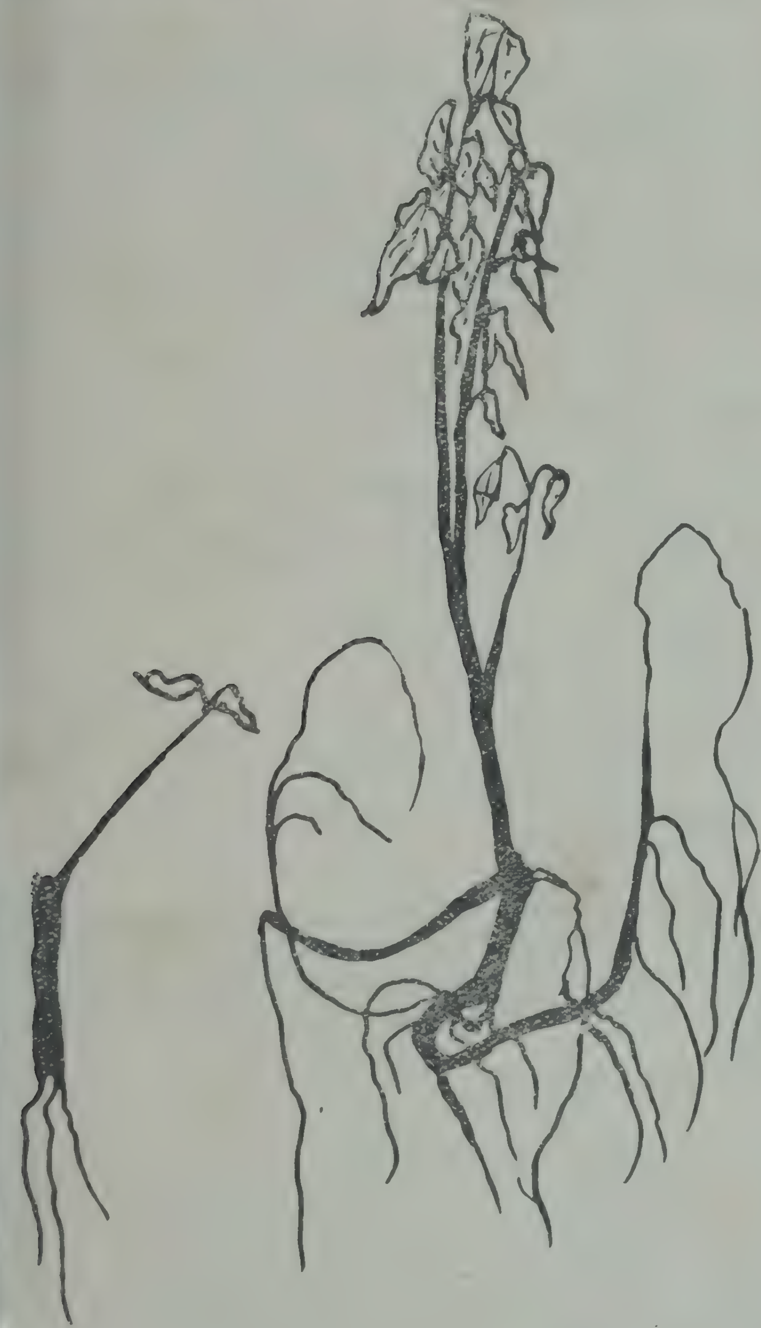


FIG. 11—How growth of mulberry is affected by preparation of soil. On the left cutting planted in badly prepared and on the right cutting planted on well prepared soil. Comparative growth during the same period.

21. Bush mulberry.

Bush mulberry is cultivated in fields like other agricultural crops and can be grown from cuttings, seeds, seedlings, rootstocks and sticks. The common practice is to grow it from cuttings.

22. How cuttings are obtained.

If the sticks of an existing bush are allowed to mature they make good cuttings. Unripe green sticks should not be used. Old twigs and branches of trees do not make cuttings. Such trees should be pollarded or their larger branches pruned and the new shoots which come out make good cuttings as they mature in the course of about three or four months. Sticks of the thickness of lead pencil to a finger are suitable for use. They should be made into lengths of about six to eight inches being placed on a log of wood and cut with strokes of a sharp heavy *dah* so that the cut ends may not split or the bark displaced. The cut should be slightly oblique. The cuttings thus obtained are best arranged lengthwise with the buds pointing in the same direction and tied up in bundles. They are best prepared at the time of planting preferably under a shade and if not planted the same day should be preserved in a pit covered with earth or green grass and leaves. Hot sun is to be avoided. The sticks keep for a week or more and if kept for a longer time are better covered with moist earth or leaves. With care sticks can be transported to long distances and over railways and steamers.

23. How mulberry seeds are obtained.

Mulberry trees bear fruits in spring after the cold weather and the fruits ripen in March, April or May. Bush mulberry does not fruit. Ripe fruits which fall off from the tree of themselves or when the tree is shaken should be collected early in the morning before they begin to ferment and placed in a pot or bucket with plenty of water. They should be crushed and kneaded with hand in water. The seeds will settle at the bottom and the water with the pulp of the fruits is poured out. With a few changes of water in this manner clean seeds will be obtained which should be spread out on tray or cloth and dried in the shade. The seeds can be sown immediately or stored but they are best used up the same season. Germination is affected if kept longer.

24. How seedlings are obtained.

Seeds should be sown in well prepared and manured seed beds with precautions against waterlogging or in pots or boxes like those of cabbage and cauliflower. The soil should be kept moist with frequent watering. Seeds do not germinate unless the earth is moist. The seedlings can be transplanted when about four to six inches high.

25. How rootstocks are obtained.

Rootstocks of old bushes can be uprooted after the bush is pruned, long roots and rootlets pruned off and the rootstocks can be planted which will throw up shoots to form a bush.

26. Forms of bush mulberry.

In bush form mulberry can be grown as separate scattered bushes or as continuous hedges. Scattered bushes are best three feet apart from centre to centre of the bushes both ways. Similarly hedges are best the same distance apart from centre to centre. Planting is frequently done closer but at the expense of quality of leaf due to want of sufficient aeration and light. (Fig. 12).

27. Planting of cuttings for bush.

Cuttings are planted in the soil (Fig. 13) in a slightly slanting position about $1\frac{1}{2}$ to 2 inches apart and with buds pointing upwards. Buds will not germinate if pointing downwards. The cuttings are thrust into the earth with hand and all slanting in the same direction. The earth should be sufficiently loose so as not to displace the bark. Cuttings with displaced and injured bark will not grow. They are better wholly underground with about half an inch of earth above the top. When planting is done in moist rainy areas in the rains the tops are better left uncovered and slightly projecting out of the earth. After planting the soil should be pressed down with hands so as not to leave empty spaces or gaps round about the cuttings. When planted in soft muddy soils no pressing is necessary, the cuttings being simply thrust into the mud.

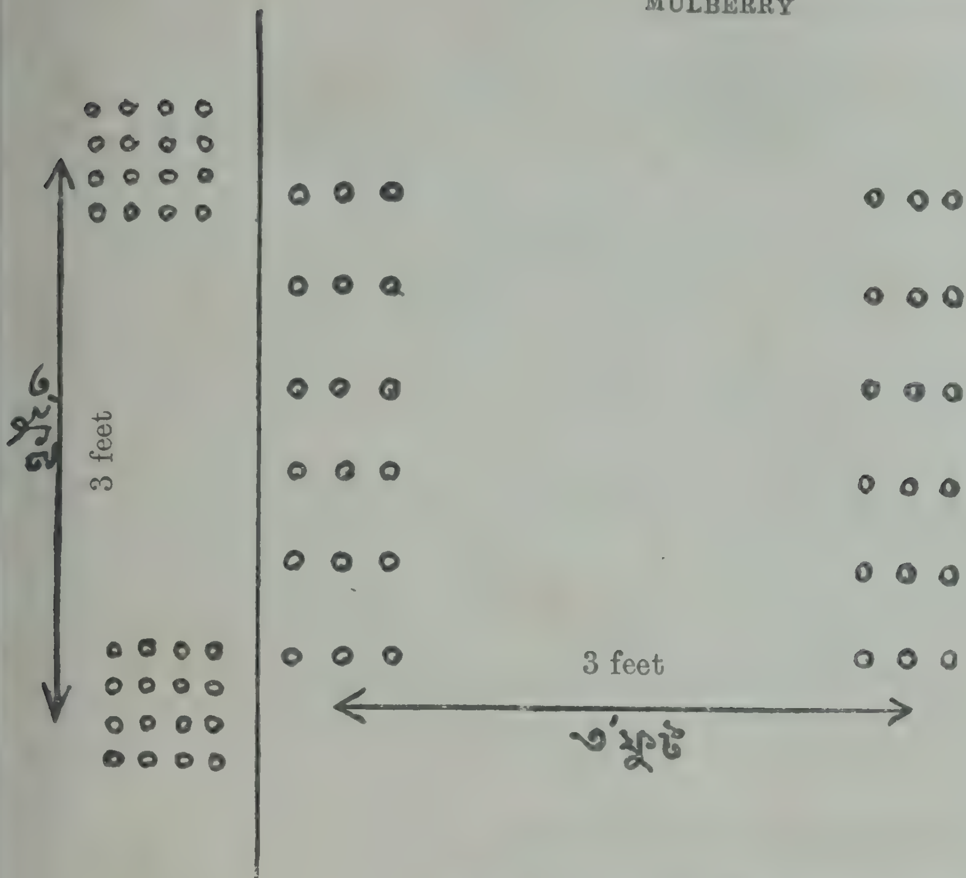


FIG. 12—Method of planting bush mulberry. Scattered bushes on the left and hedge form on the right. The dots indicate cuttings.

28. Planting of seedlings for bush.

Seedlings about four to six inches high can be planted out for bush in both scattered and hedge forms. For this purpose a hole is better made for each seedling with a pointed stick, the root of the seedling thrust into this hole and the earth pressed down all round.

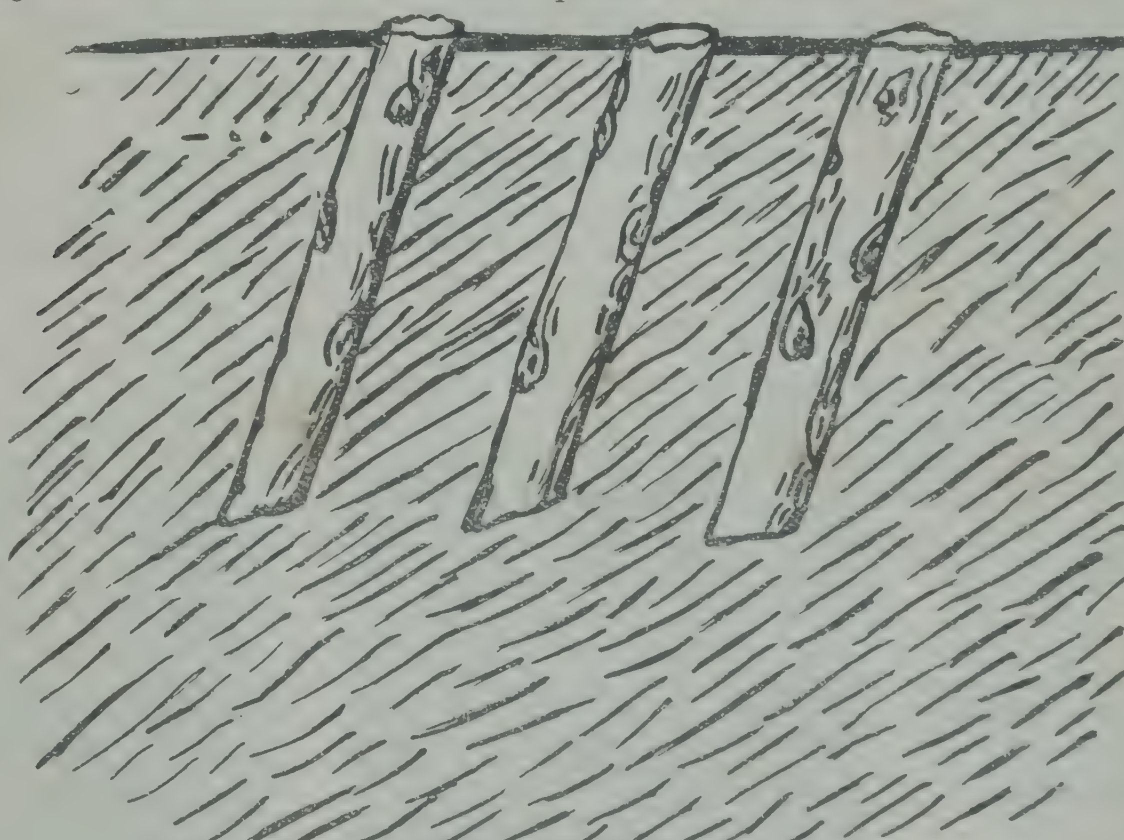


FIG. 13–Method of planting cuttings. The cuttings are planted in the soil in a slanting position.

29. Preparation of land and planting bush.

The success of a planting depends on the preparation of the land. The best method of preparation is as follows. Just at the close of the rains before the soil hardens dig the soil with

spade to a depth of about a foot to a foot and a half. The greater the depth the better. If roots of any trees be there they should be uprooted and removed. Then about February and March the earth should be pulverised with ploughing and laddering. Ploughing in hot weather will cause roots of grasses and weeds to dry up and then to rot afterwards. The land requires to be manured with farmyard or any other manure in the course of these ploughings. Then planting can be done after early showers or any time during the rains if care is taken about drainage.

Local practices are followed of planting at different times. For instance in Bengal, planting with cuttings is done after the rains in Malda, Murshidabad and Birbhum districts, in the rains generally with root stocks in Bankura district and with layerings in Rajshahi district and in spring with irrigation in Midnapur district. Planting after the rains suffers from one great disadvantage in that in case of drought in winter much of the planting runs a risk of failure.

For actual planting both in scattered bush and hedge forms ropes are stretched from end to end of the field and bothways in the case of scattered bushes three feet apart and the lines marked. The intersections of the lines form the centres for scattered bushes and all round these centres 9, 12 or 16 cuttings (or seedlings) are planted. In the case of hedge form the line forms its centre and one cutting or (seedling) is planted in this line and one cutting on either side at three inches distance. Cuttings are planted in this manner at distances of six inches along the whole line. Care to have the lines of scattered bushes as well as hedges straight is very necessary for facilities of interculture and weeding with hand or bullock ploughs. When once planted the plantation lasts for many years. Therefore care at the time of planting pays and saves a lot of inconvenience afterwards.

30. Growing hedge form of bush from seeds.

The hedge form of bush can be grown directly from seeds. For this purpose a small furrow is made along the line with a pointed stick and another furrow on either side of this line at a distance of about three inches. Seeds are dropped in these furrows so as to have one or two seeds at intervals of about one and a half to two inches and the furrows covered up with earth. The soil requires to be kept moist with irrigation or sowing can be done early in the rains when showers keep the earth moist. Hedges three feet apart are thus obtained. If too many seedlings be close together they do not grow and some of them should be uprooted and planted elsewhere or utilised in filling up gaps. If the seedlings are left about $1\frac{1}{2}$ to 2 inches apart they grow satisfactorily.

31. Growing hedge form of bush from layerings.

Whole sticks can be laid in furrows about one to two inches deep along the lines and covered with earth. Planting is done in rainy season with care about drainage or in sandy soils in which the water percolates down easily.

32. Treatment of bush mulberry.

Bush grown in Bengal method is pruned at the time of every rearing. It is not allowed to grow to a greater height than about three to five feet (Fig. 14). If the soil is manured and

FIG. 14–Bengal bush mulberry. Harvesting on the right.

cultivated after each pruning the bush grows afresh thickly and yields of about 20,000 to 21,000 lbs. plucked leaves per acre are common or about double this weight with twigs. The requirements are timely pruning (even if no rearing be done), timely interculture and weeding and manuring.

No irrigation is practised. Pruning i.e. harvesting is adapted to the seasons of rearing. In well prepared and manured soil from cuttings planted about June a bush about three to four feet high can be obtained by about October. The leaves can be plucked and fed to the worms. Leaves will again be available for plucking about March and again about June, July. Pruning is to be done at this time. Pruning before this may shake the cuttings. From now on pruning is done at every rearing season, usually at the base. The pruning about August is however done leaving about a foot of the stems which throw up shoots. When pruning at a little height above roots sickles are used but *dahs* when at the base. In the course of about three or four years the roots thicken forming a head (*murrah*) which does not throw fresh shoots well. Therefore just after the rains, about September these *murrahs* are cut off with *dahs*, thus allowing shoots to grow from a little below the head. After about ten to fifteen years fresh planting becomes necessary. In several districts a system of adding earth to the bush mulberry field is followed, usually from a ditch dug round the field. The result is that the mulberry field is raised from the surrounding area and on account of additions of earth and growth of fresh shoots the same planting can continue for years, fields even a hundred years old being known. The bad effect of such earthing is that these fields become unfit for cultivation of other crops. In several districts such raised lands are lying fallow since sericulture was abandoned. In some places mango trees have been grown on them.

If pruning is done with pruning shears shown in Fig. 15 with care not to split the stems, the plants from very satisfactory bush.

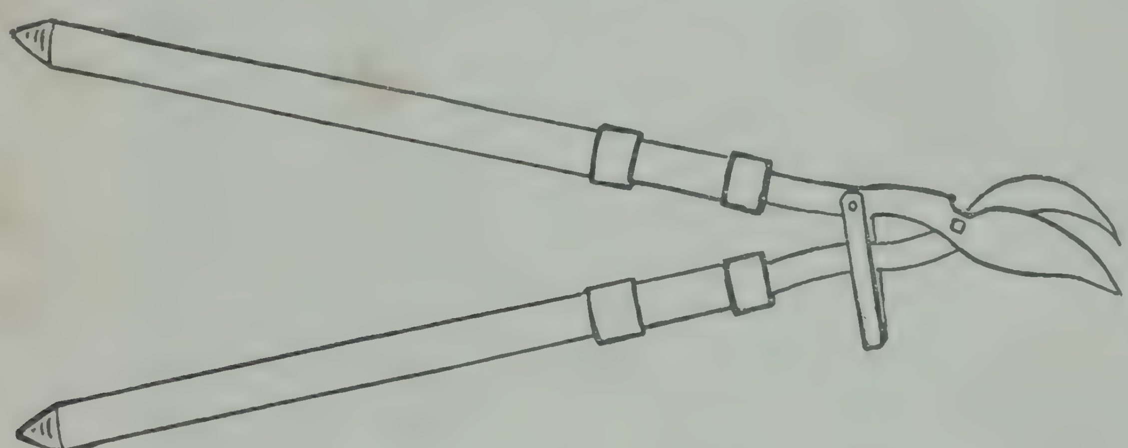


FIG. 15—Pruning shears.

Bush grown from cuttings in Mysore and Madras is slightly different from that of Bengal in that a less number of cuttings is planted at the place, the mulberry is less bushy, leaves are plucked for feeding the worms and pruning at the base is given only once in the rainy season.

Interculture and weeding :—After each harvesting in Bengal method it is necessary to dig and weed the fields. After the rainy season it is necessary to give a deep digging with spade. The field is best manured at the same time if possible. At other times shallow surface digging serves the purpose. This can be done with bullock plough or better with hand plough (Fig. 16) which can be used also in weeding when necessary. Bullock ploughs unless carefully used pull out many rootstocks. A second manuring in the hot weather is desirable.

Manuring :—Bush mulberry from which so many crops of leaves are taken are better manured two times in the year once after the rains and once again in the hot weather. For manures to be used see section 44.

Irrigation :—When irrigation is possible a higher yield of leaves is secured. After irrigation it is necessary to loosen the surface soil before it is dry. Otherwise full benefit of irrigation cannot be expected. In a small area in Mysore mulberry is grown under irrigation from wells, irrigation being given once every week and harvesting from base is done in every rearing.

FIG. 16—Hand plough.

33. High bush.

The cultivation of high bush has been worked out after the method of bush cultivation followed in Japan as a field crop. The plants are grown from grafts. Their stems are kept short, grow branches at the top and thicken in course of time. They last for about eighteen years in Japan after which fresh planting becomes necessary. Under Indian conditions they will probably last longer. First of all seedlings are grown and their roots are used as stocks on which desirable scions are grafted and planted out.

34. Growing seedlings for use as stocks.

Seedlings can be grown in fields as described for hedge form of bush (Section 30). If seedlings are grown in pots or boxes they require to be transplanted into fields in the same way as

described for bush cultivation (Section 28) but about two inches apart. It is necessary to see that their roots when inserted into the holes remain straight. If the seedlings are planted about two to three inches apart they grow well to serve as stocks for grafting. If seeds are sown early in the rains about June in well prepared and manured soil and if there be timely showers or if irrigation can be given, the seedlings grow to a height of about four feet by about September in the plains and their stems become as thick as the little finger and they become quite suitable for use as stocks for grafting.

35. Selection of scions.

It is the scion which grows into tree. Quick growing varieties with large leaves of good food value are best selected for use as scion in grafting. Seedlings may be of any variety. It is necessary to make provision for scions beforehand. Mature stems of bush mulberry or mature new shoots of trees can be used as scions for pen-grafting. For root grafting thin mature twigs are better used and trees of desirable varieties should be grown for the purpose.

36. Preparation of grafts.

Grafts can ordinarily be prepared in three different ways viz., pen-grafting, root-grafting and bud-grafting.

Pen-grafting (Fig. 17):— Uproot the seedling. If the root breaks or splits it does not do well. If the seed bed is watered well and the soil softened the seedlings can be pulled up easily with hand. Side roots and rootlets may be pruned off and also the tip of the main tap root with a sharp pruning knife. Cut off with a clean slanting cut the stem so that the cut may extend partly over the root and partly over the stem. Select a scion of the same thickness as the stock with two to three uninjured buds which should point away from the stock. Cut the base of the scion with a cut which will fit the cut of the stock so that the cut surfaces of their bark touch.

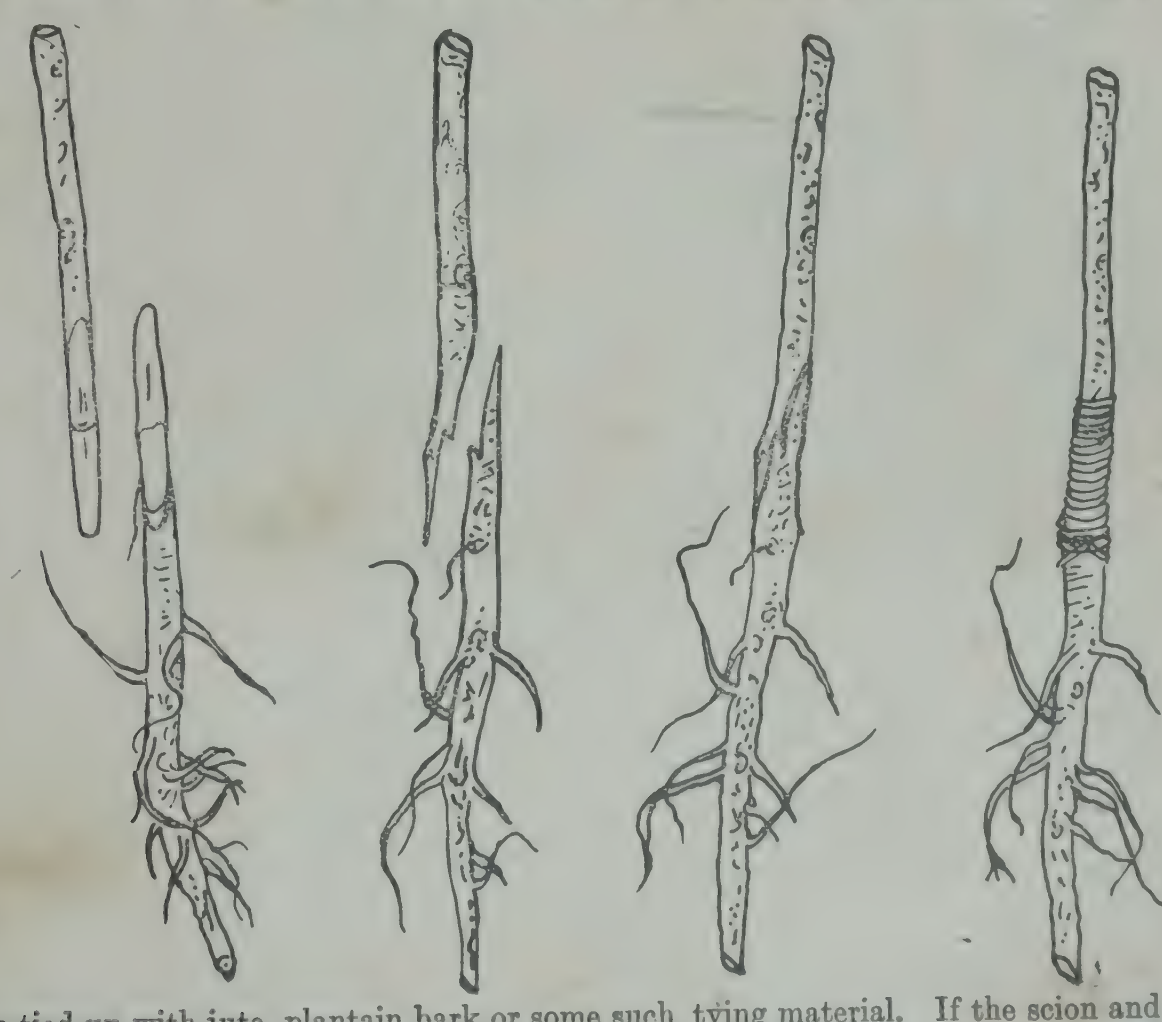


FIG. 17—Pen grafting.

They can now be tied up with jute, plantain bark or some such tying material. If the scion and the stock get displaced the graft will fail. Therefore after the cuts are ready they are joined

together, held tight with hand and a mark applied on a side and a notch incised at the position of the mark on the cut faces of both and then notches are fitted into each other. Now there is no risk of displacement and tying is done. The graft is ready to be planted.

Root grafting (Fig. 18) :— Take only the white root of the seedlings by cutting off the stem with a clean cross cut with a sharp *dah* so that the bark may not be injured. This root forms the stock and the rootlets may be pruned off. For scion take a ripe thin twig from the desirable variety. At about half inch from the base of the scion have a cross cut to about two-thirds of

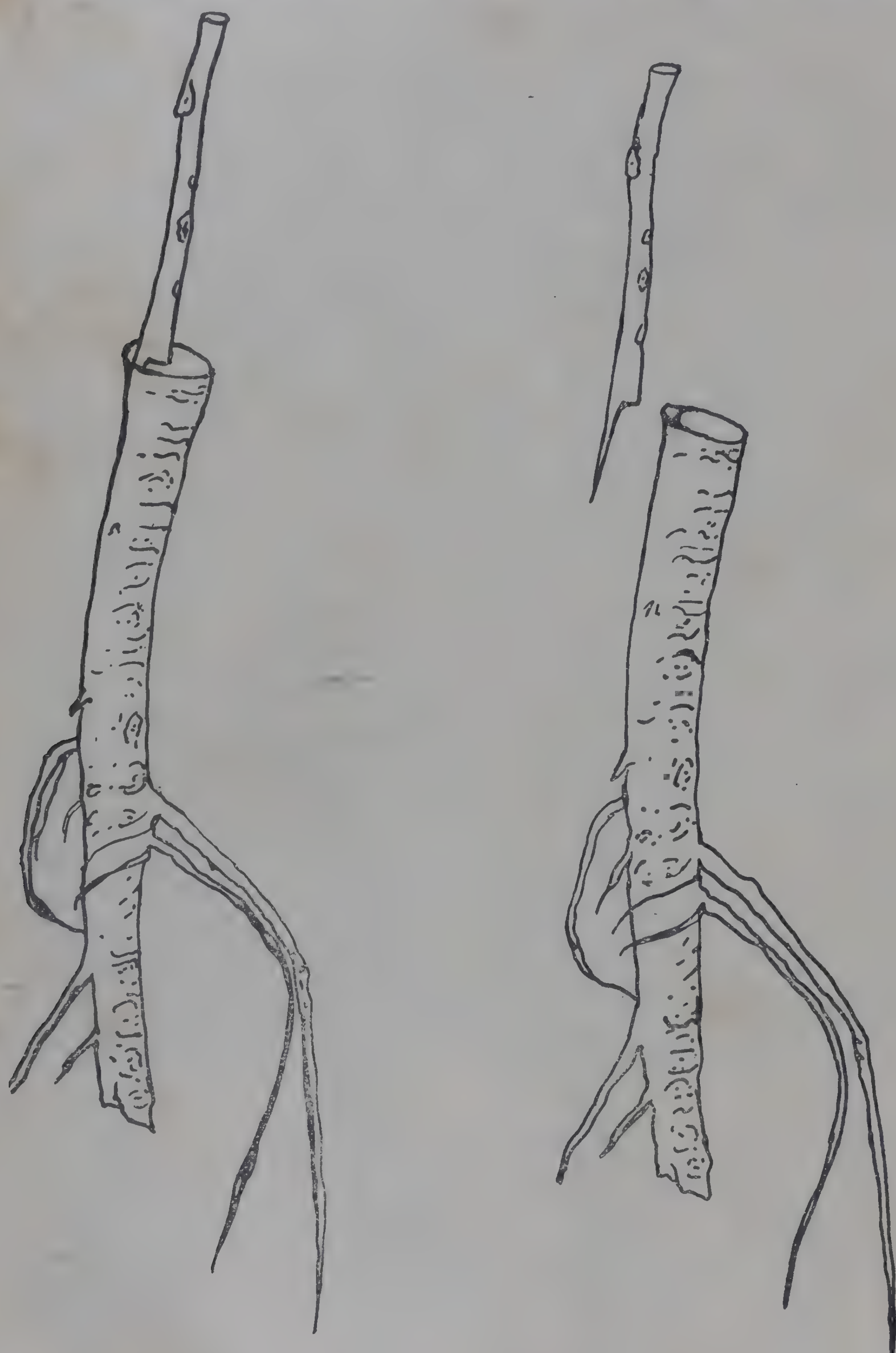


FIG. 18—Root grafting.

its thickness from one side and remove the portion below so as to have a thin tongue. Scrape the back of the tongue slightly to expose the green tissue. Now hold the root with one hand and with the other insert the tongue of the scion between the bark and wood of the root so that

the cut surface of the wood of the scion rests on the cut surface of the wood of the root. The scion must have two uninjured buds pointing upwards. The graft is now ready and can be planted with care to see that the scion does not get displaced. Not only roots of seedlings but those of grown up trees can be used as stocks.

Bud grafting (Fig. 19) :— Select a sound bud preferably on a new growing but mature stem or shoot of a desirable variety and cut it out with a sharp budding knife so that there is a little bark all round the bud and a little wood inside. On the stem of the seedling a little above the root have a cut in the shape of a cross. The arms of the cross may extend so far as to allow the bark to be separated from the underlying wood and the bud inserted in the cut with its cut surface sitting on the wood. The displaced corners of the bark of the stock are placed on and hold the bark of the bud but leaving the bud itself free, which must point upwards. A tying is now given leaving the bud free to grow. The stem of the seedling is cut off with a clean cut a little above the inserted bud. The graft is now ready to be planted. Buds can be grafted in this manner on the stem or branch of a growing tree.

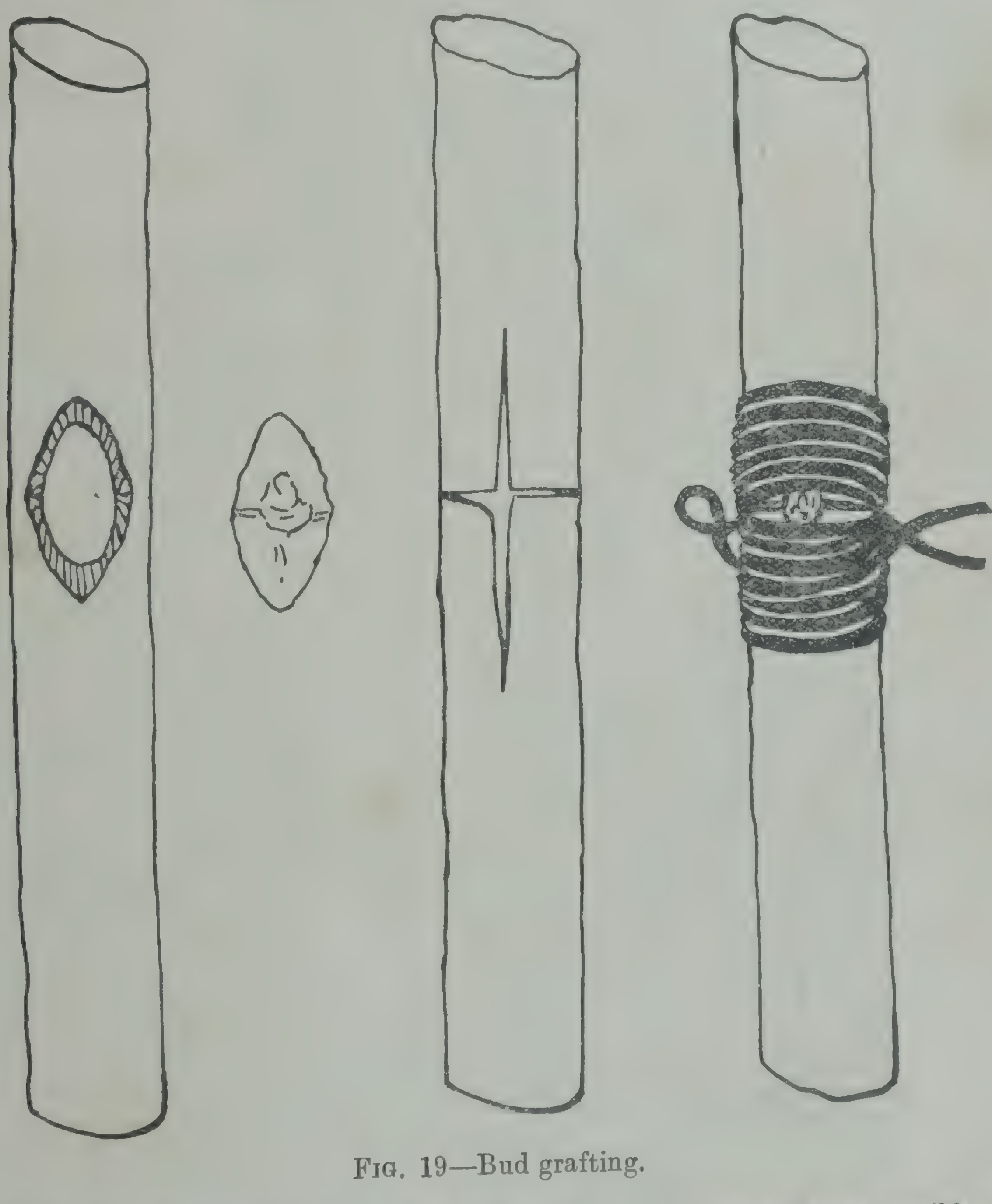


Fig. 19—Bud grafting.

N.B.—Grafts should be prepared with fresh stocks and scions as far as possible. At least cutting and joining must be done before the juices dry up. If there be delay in planting the prepared grafts they should be preserved under moist earth or green leaves, etc.

37. Preparation of land and planting grafts for high bush.

The land should be thoroughly cleared of tree and other roots and prepared in the same way as for bush. Now mark straight lines five feet apart and dig trenches along the line about a foot wide and a foot deep and keep the earth on one side of the trench. Place manure in the trench bed which should be dug and the earth mixed with the manure. The trench is now ready for receiving the grafts, which are stood in its middle two feet apart and the trench filled up and the earth pressed down. The tops of the grafts are nearly level with the surface of the field and earth is made to cover them and to form a sort of a low ridge along the row. Fig. 20 shows the method of planting from right to left. Planting can be done early in the rains in June after a few showers moisten the soil or just after the rains about September. With attention to drainage planting can be done even in the rainy season.

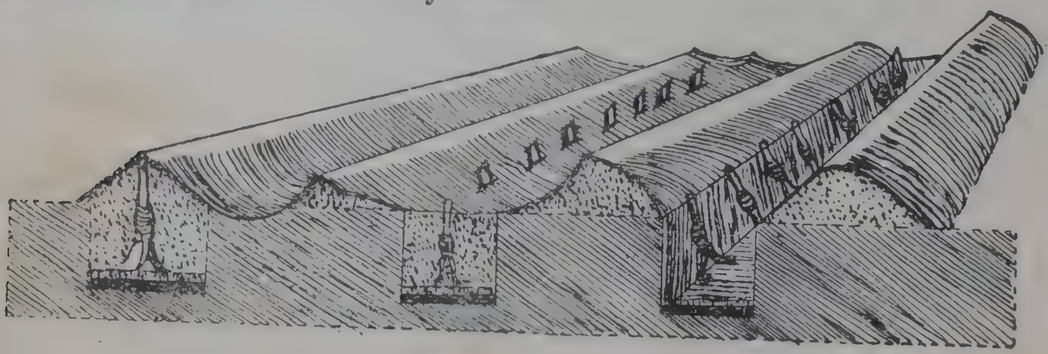


FIG. 20—Planting of grafts for high bush. How planting of grafts is done (after Yendo and Higuchi).

38. Treatment and care of high bush.

With proper preparation of land and planting the shoots which come out in the course of a few days grow vigorously. Fig. 21 shows a plantation started in July at Berhampore Sericultural

FIG. 21—New high bush plantation at Berhampore about three months old. Planted in July. It is ready to be pruned at its proper height.

Farm and only about three months old. It is necessary to allow one vigorous shoot to grow from the graft and to watch and break off side shoots up to the height intended for the stem which can be kept as high as desired from about six inches to two feet. One-and-a-half to two feet is a good height which allows of easy plucking of leaves from the branches growing from the top of the stem. When the stems mature sufficiently up to at least about a foot above the intended height they are cut off with pruning shears or sharp knife without splitting the stem or injuring or displacing the bark. All the stems in the field should be cut at approximately the same height. Branches will grow from the top of the stems. Fig. 22 shows how branches have grown from the top of the stems

Fig. 22—How branches grow from the top of the stem of high bush.

of a high bush plantation photographed after plucking of leaves. Fig. 23 shows a high bush plantation in the background. Scattered form of ordinary bush is sprouting after harvest in the foreground. Leaves are plucked and fed to the worms. Plucking has to be done with care so that the bark of the stem is not injured. For this purpose a flat iron ring about half-an-inch

wide and with a sharp cutting edge rivetted to it is used (Fig. 24). It is fitted on the index finger with the cutting edge pointing upwards and the stalk of the leaf intended to be plucked is held over the cutting edge between the index finger and the thumb and the stalk cut with an upward jerk. The lower part of the stalk of the leaf is left on the stem. With a little practice plucking can be done with both hands into a basket slung from the neck of the plucker. Broad leaved varieties are most suitable for high bush. Plucking of small leaves takes longer time and is rather tiring.

FIG. 23—Ordinary Bengal bush in the foreground sprouting after harvest and high bush in the background.

High bush is better pruned twice, once at the beginning of the rainy season after a few showers have added some moisture to the soil. Pruning is done with pruning shears at the base of the branches leaving only about a quarter of an inch of the base. Care should always be taken not to split the stem or injure or displace the bark. Repeated prunings if properly done will cause a thick head to be formed at the top of the stem. The wider this head the larger the number of branches it will throw out after pruning (Fig. 25). The second pruning is given about September but this time of the branches leaving about nine inches to a foot of their bases which throw up fresh shoots. Sometimes the high bush shows a tendency to flower and fruit heavily. The second pruning stops this. Flowering is always at the expense of leaves and if it occurs flowers are better broken off.

The soil should be dug twice. Manure should be applied in furrows dug on either side of the row of stems and mixed up with the soil a little below the surface and covered up. Two applications of manure if possible are helpful, once before and once after the rains or if applied once it is better done before the rains.

High bush plantation has been introduced only recently into India. In Japan it lasts for about 18 to 20 years.

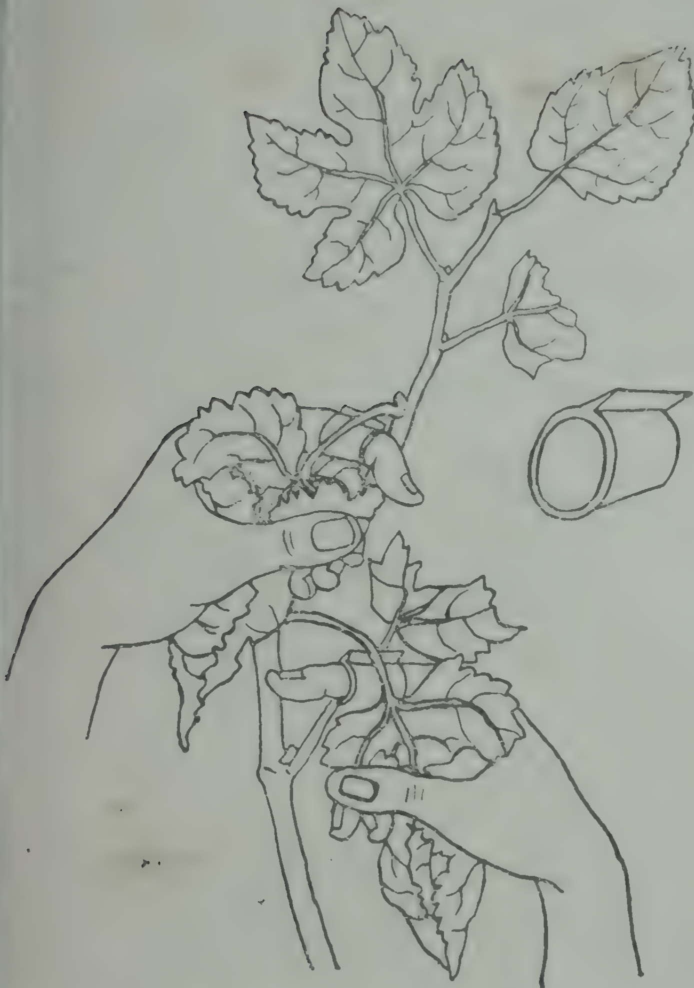


FIG. 24—Leaf plucking ring. Leaf being plucked with both hands.

FIG. 25—Pruning of high bush. A pruned stem on the left.

39. Tree mulberry.

Lands which are not suitable for bush or high bush for instance, high lands, slopes and hill sides should be planted with medium or high trees.

40. Growing young trees in nursery.

The best plan is to grow young trees from grafts planted in a nursery in rows two feet apart and one foot apart in the row, allow only one shoot to grow from each graft and prevent side shoots from growing up to the height of the stem desired for the tree. When the new shoots are about six feet high and mature the stem should be pruned at a height of about three feet for medium trees and about five feet for trees and allow three branches to grow from the top. Such trees can then be transplanted into their permanent places in the plantation.

Young trees can also be grown from seedlings. When the seedlings in the seed bed are about four feet high they should be uprooted, their stems pruned low leaving only two uninjured buds, their rootlets and tip of tap root pruned and they are then planted in a nursery in the same way as grafts, one foot apart in the rows which should be two feet apart. One shoot is allowed to grow from the pruned stem and the shoot treated in the same way as in case of grafts. Unless the seedlings are treated in this manner straight stems for future trees are difficult to get.

41. Planting and care of medium trees.

The land should be free from the roots of trees, which if present prevent the mulberry trees from spreading roots properly and also from grass roots. If the land is prepared initially in the same way as for bush and high bush, growth of the trees is satisfactory. For planting out medium trees pits are dug six feet apart both ways about $1\frac{1}{2}' \times 1\frac{1}{2}'$ and manure is applied at a depth of about

a foot and mixed well in the soil. The pits can be left open until actual planting is done eith in the early part of the rains or at the close of the rains. Young trees are uprooted from th nursery, their rootlets pruned off lightly, their leaves also cut off leaving the bases of the stalk and they are thus planted in the pits which should be filled up and the earth pressed down an more earth added round the stem so that rain water may flow off and not settle at the root Unless the leaves are pruned off they wilt and dry losing some part of the sap of the plant itself New shoots soon sprout and grow. Care should be taken in pruning and training the mediun trees. The three branches which grow from the top of the stem should be pruned when they mature and become as thick as a finger or thicker leaving about a foot. Branches will grow from them and they in their turn should be similarly pruned allowing tertiary branches to grow and bear leaves. These tertiary branches should be pruned off every year or twice every year as in the case of high bush according to vigour of growth. If the trees can be trained in this manner sufficient leaves will be obtained which should be plucked and fed to the worm except at the time of pruning when twigs bearing leaves can be cut off.

The soil of the plantation is better dug once after the rains and once again in case of heavy growth of weeds. Manure should be applied once in furrows dug round the tree until the trees grow sufficiently. Grown up trees may not require manure (Fig. 27). According to soil and locality medium trees may take about two to four years to get properly settled and stand plucking.

Fig. 26—A medium tree, grown from a graft.

42. Planting and care of trees.

Trees if left to grow attain a great height. But for silkworm rearing it is necessary to have abundant leaves and to pluck the leaves without much difficulty. Therefore they are pruned and trained. They should have a chance of spreading roots and therefore the place should be free from other tree roots. It is possible to grow temporary agricultural crops in between the trees.

For planting trees pits should be dug 12 to 15 feet apart in the case of regular plantation practically in the same way as for medium trees and six feet high young trees from the nursery planted out. It may be necessary to protect them against the attention of cattle, goats, etc. Some thorny branches may be tied round the stem.

Trees require to be pruned and trained in the same way as described in case of medium trees and it is possible to get abundant leaves from them. According to the soil and locality trees may take about three to eight years to get properly settled and to stand plucking (Fig. 27). Until then more than what is available in pruning is better not taken. It is essential to prune mulberry

Otherwise the leaves tend to grow smaller and the yield too is not satisfactory. Until the trees grow it is advisable to keep the soil up to a distance of about four feet allround dug and loose.

FIG. 27—A tree putting forth shoots after pruning.

43. What form of mulberry to grow.

For rearing univoltine worms once in the year tree mulberry serves the purpose very well. But when four or five crops of cocoons have to be reared with multivoltine worms trees alone are not sufficient and require to be supplemented by bush and high bush. Through practical experience the multivoltine rearing areas have developed the system of bush cultivation yielding several crops of leaves during the year. But as already pointed out bush mulberry is the most costly of all forms and the quality of leaves is poor. High bush is less costly to maintain, medium trees cost still less and trees cost hardly anything. It is possible to have two crops of leaves from trees, once after spring and once again about October. Yields of high bush and medium trees have yet to be found out for different localities. From a tree plantation about 6,000 lbs. of plucked leaves can be expected in a year per acre with about 300 trees, from a medium tree plantation about 8,000 to 9,000 lbs. from high bush plantation about 12,000 to 18,000 lbs. and from a bush plantation 20,000 to 24,000 lbs. with proper cultivation. These figures can be taken as maximum yields actually obtained under Bengal conditions. Yields necessarily vary with the quality of the soil and the method of cultivation practised. In order to keep down the cost of production of leaves and thus of cocoons it is advisable to grow more of trees and medium trees and less of high bush

and still less of bush. Young worms do well on bush leaves and as they feed only small quantities of leaves a small area of bush can feed a large number of young worms. As the worms grow leaves of high bush, medium trees and trees can be used and if this method is followed cocoons of good quality are produced.

44. Manures for mulberry.

Trees when grown up and settled do not require any manuring. Bush and high bush need it as leaves are harvested from them several times in the year. Manuring accompanied with cultivation is essential to ensure abundant growth of leaves and leaves of good quality. It is from the soil that the plant draws its supply of food materials in order to be able to grow and bear leaves heavily and these food materials require to be replenished in the shape of manures. According to Dr. Hiratsuke, Director of the Imperial Sericultural Experimental Station, Nakano, Japan, the worm in its last stage when the largest quantity of food is taken uses 25 per cent of digested solid and 65 per cent of digested nitrogen in the production of the silk substance in its glands. This emphasises the importance of nitrogenous manures for mulberry. He recommends 132 to 188 lbs. of nitrogen to be applied in two instalments per acre and sulphate of ammonia as the best form. In order to enable the plants to make proper use of the manures applied it is necessary to retain moisture in the soil, to keep the soil cultivated so as to have aeration and to keep down weeds. If weeds are allowed to grow they consume the manure. If the surface soil is kept in a loose condition by cultivation moisture is retained in the soil. If it is necessary to remove weeds they should not be thrown out but heaped between the rows of plants and they soon rot thus serving as manure. Covering the weeds with earth converts then into manure quickly. Bulbs and rootstocks of *mootha* grass (*Cynodon dactylon*) and roots of grasses like *Saccharum* must be removed from the fields.

Manures commonly used by the rearers of Bengal are farmyard manure, silt from tank beds and ditches, oil-cakes and a weed, called *bhode*, growing in tanks and marshes. But of the artificial manures sulphate of ammonia is extensively used in Japan and other countries. In Mysore the Sericultural Department recommends a combination of sulphate of ammonia and groundnut cakes. Manuring depends a good deal on the availability of manures.

Manures which can be used for mulberry are broadly divisible into the following viz. :—

(1) Artificial manures, obtained mostly as bye-products of various industries. Sulphate of ammonia is the most useful but its continued use without farmyard manure or a manure of vegetable and animal origin proves injurious to the soil.

(2) *Animal manures* :—Dung of cattle, goats, sheep, etc. and also of man and bones etc., of dead animals form good manure. Cowdung though a very useful manure is rather scarce on account of its use as fuel. Nightsoil is extensively used in Japan and China but is rejected in India on account of prejudices against it. It is possible to be used in composts described below and if this can be brought into vogue a highly valuable manure now wasted can be utilised with great benefit.

(3) *Vegetable manures* :—All rejected parts of agricultural crops, weeds, green or fallen leaves of trees, rank plant growths on waste lands, weeds growing in tanks and marshes, in fact all plant parts except thick stems and branches can be converted into manure through composting i.e. subjecting them to a process which converts them into manure in the course of about four months or so. This is known as compost manure or simply compost. It has been found out through experiments and trials that compost forms a perfect manure capable of supplying all the materials necessary for healthy growth of crops, vegetables and fruits and for increasing the health and disease-resisting capacity of cattle and human beings supported by these crops and vegetables. King in his *Farmers of Forty Centuries* has recorded how in some places of China peasants though poor and possessing small holdings are able to produce abundant crops of a kind which has maintained them in robust health through forty centuries. All unused parts of the crops are returned to the soil in the form of compost. Sir Albert Howard found that bullocks fed with Napier grass etc. manured with compost resisted foot and mouth disease while other cattle fell victims to it. He has also recorded that crops manured with compost not only grew well but also proved resistant to insect pests. Use of compost is now advocated in all countries and instances of its usefulness are frequently published. For instance it has been recorded that in a

boarding school the boarders fed with vegetables etc., manured with compost have been observed to resist several ailments from which they suffered before. Rai Bahadur Dr. G. C. Chatterjee, well known Bacteriologist of Calcutta has found that his sugarcane crops when manured with compost resisted diseases and pests better and yielded *gur* of much better quality than when manured with artificial manures. The Agri-biochemist (N. N. Ray) of the Bengal Sericultural Department has found on analysis that compost prepared in Berhampore Sericultural Farm contains all the materials required for healthy growth of mulberry. Experiments with compost are being carried out by this department and it has so far been found that worms fed with bush mulberry manured with compost suffered less from flacherie and grasserie diseases than other worms. Farmyard manure comes near to compost. But cowdung is not available in sufficient quantities, while there is no want of materials for preparing compost.

Preparation of compost:—Procure the materials mentioned above. If the leaves be succulent like those of water hyacinth they are better dried in the sun to some extent. Hard sticks like those of bush mulberry or cotton stems are better crushed by being placed on roads over which bullock carts ply. Leaves or soft materials are better mixed with hard sticks etc. in the proportion of about three to one. Collect urine from cattle sheds by having a sort of a drain in the shed causing the urine to flow into a pot. In the absence of urine, earth soaked with urine in the cattle shed can be used and such urine earth can be stored for use when necessary. The urine earth can be removed from cattle sheds up to a depth about nine inches and stored, fresh earth being added to the shed. In the absence of urine or urine earth fresh dung from cattle shed with which some urine is always mixed can be used. In the absence of dung or urine ammonium sulphate can be used.

Dig a pit in the ground preferably at a place which is not likely to go under water, about five or six feet wide, about a foot deep and as long as can be desired or possible. Heap the excavated earth on the edges all round. Spread a layer of the materials on the bed of the pit and sprinkle it all over with water mixed with urine earth or fresh cattle dung or urine or ammonium sulphate solution, so that the layer becomes wet with it. Now spread another layer on top of the first layer and wet it similarly. In this manner layer after layer should be arranged up to a height of about four feet or higher if there be sufficient materials. It is necessary to keep this heap moist with watering on top. But care should be taken not to flood it with water. For the same reason in the rainy season precautions should be taken against its getting flooded and in this season the heap can be arranged on the surface of the ground instead of in a pit. After about a fortnight the entire heap requires to be turned over with spade or fork beginning from one end and finishing at the other end. Moisture should be maintained and turning repeated. The materials will crumple into powdery manure in the course of about four months. The process can be quickened if some materials from a heap which has made some progress be mixed in a new heap. If compost is made in a pit inside an enclosure of some sort for privacy and two planks or sufficiently strong wood or bamboos are placed across the mouth of the pit all members of the family can ease themselves there. The faeces and urine thus added to the compost add greatly to its value as manure. Such a compost pit has been described as a gold mine for the peasant family. The faeces is quickly converted into manure leaving no bad smell.

Bhode :—Bhode used in Bengal as manure is a kind of compost. It is spread between the rows of bush and allowed to rot. The result is better if compost is prepared with it and then applied.

Oilcakes :—Mustard, castor, groundnut and all oilcakes can be used as manure. They should be powdered and mixed with earth and spread. If they are soaked in water and allowed to ferment and rot and then mixed with earth and spread the result is better.

(4) Silt of tank, ditches, etc., is a good manure. But sufficient quantity of it can hardly be available.

N. B.—Silt, compost or farmyard manure should be used at the rate of about sixty cartloads per acre and oilcakes about 18 to 20 mds.

45. Diseases and pests of mulberry.

The diseases and pests of mulberry observed or reported from different places in India and Burma are listed below and a short account of them is given. Although the list is fairly long only

Tukra and mildew occur frequently and are fairly serious. Others may prove bad only occasiona[lly] and not in the same locality. Very little attention has so far been paid to this aspect of mulber[ry]. Investigation may reveal other pests and diseases.

I. Diseases :—
(1) Tukra.
(2) Shownia.
(3) Bishalpata.
(4) Naicha.
(5) Chittidhara.

II. Fungal pests :—
(1) Mildew on leaves.
(2) Fungi on roots and stems.

III. Insect and other animal pests :—
(1) Scale insects on stem.
(2) Longicorn beetle borers in stem.
(3) Caterpillar borer on stem.
(4) Thrips on leaves.
(5) Hairless caterpillars on leaves.
(6) Hairy caterpillars on leaves.
(7) June beetles or cockchafer beetles on leaves.
(8) Weevils on leaves.
(9) White grubs or cockchafer grubs on roots of seedlings and young plants.
(10) Termites (white ants) on roots.
(11) Mole rats on roots of fairly grown-up plants.

Tukra :—This disease so far recorded from Bengal is characterised by the crumpling o[f] the leaves especially at the tops of young plants (Fig. 28) or bushes or branches of medium o[r] large trees. The bush mulberry suffers most and in bad cases the leaves on entire shoots are affected. The leaves are crumpled, knarled and distorted so as to form a rather compact hard knot. Inside the folds of the knot a small white mealy-bug (*Phenacoccus hirsutus* Green) occurs frequently in large numbers. This insect was at one time supposed to be the cause of this disease.

FIG. 28—A few mulberry tops affected by Tukra disease. How they are crumpled.

The recent investigations by the Bengal Sericultural Department with the help of the Agricultural Biochemist, late N. N. Roy, have revealed an association of this disease with deficiency of phosphates in the soil. The insect is not present when crumpling commences and appears when crumpling has made some progress so as to afford a shelter to it. The insect breeds in the knot.

The disease is present practically throughout the year and occurs badly both when the plants are growing vigorously with sufficient moisture in the soil and also in the dry season when in bad cases no leaf may be obtained from the infected field at all. Practically it has been possible to rid a badly infected field in the Berhampore Sericultural Farm of this disease and to keep it

free with manurial treatment. Practical application of the results of this investigation in different seasons in cultivators' fields present difficult problems. The disease requires further intensive study.

Shownia :—(After the name of the month Sravan i.e. August)—is characterised by development of rust coloured patches on the leaves in the rainy season about August. Such leaves if fed to the worms affect their health and cause flacherie. As whole fields may be affected the disease, the cause of which is not known yet, is a problem for study. The disease is so far recorded only from Bengal.

Bishalpata :—(i.e. poisonous leaf). If there be a shower of rain after the root pruning of the bush mulberry about September, the leaves, especially the lower ones on the new shoots cause flacherie in the worms fed with them. Nothing is known about the causal agent and it is a problem for investigation. It has so far been observed in Bengal.

Naicha and Chittidhara :—Denote unhealthy conditions of bush mulberry in Bengal associated with disease produced in worms fed with them. Nothing is known about them and they are matters for investigation.

Mildew :—Mildew (*Phyllactinea coryla* (*pers*), Kars.) is characterised by formation of a film of fine white cottony strands usually on the under surfaces of leaves. In bad cases the affected leaves get discoloured and ultimately fall off. Mildew occurs both in rainy and dry seasons and is usually bad in the earlier part of winter and some-times also in early rains. With slight infestation the leaves are observed not to become unfit for use for grown-up worms. But infestation spreads rapidly and also progresses rapidly. Therefore it forms a real hindrance to sericulture and occurs everywhere.

Spraying of solutions prepared at the rate of half-an-ounce of Potassa Sulphurata in a gallon of cold water kills the mildew. The spray must be applied on the mildew on the under surfaces of the leaves. Spraying whole fields is a difficult problem. Mildew therefore calls for a proper study and investigation.

Fungi on roots and stem :—So far only one fungus has been recorded from Bengal causing rootrot of bush mulberry. A proper investigation may reveal others. In Japan several fungi are known to attack roots of seedlings and grafts and sale of infested seedlings and grafts is prohibited by law. Butler found *Coryneum mori* attacking wood of trees in Kashmir. Old trees hardly suffer but the growth of seedlings is retarded.

Scale insects on stem :—Scale insects occur on the stem and branches as small scales on the bark. They suck the sap and in most cases may kill the plant. They do not occur on bush mulberry but on medium or large trees especially those growing in hilly regions. They can be controlled by spraying or smearing them with soap solution or better with rosin compound solution.

Soap solution :—Half pound ordinary bar soap is sliced into thin pieces and boiled till dissolved in a kerosene tin and cold water is added to fill the tin full. It is used cold. Ordinary country made washing soaps can also be used but a little more of them is required. The solution is best prepared the day it is used. Half a pound soft soap can simply be dissolved in cold water and sprayed. No heating is required in this case. The easiest way of dissolving soft soap is to put the soap in a piece of cloth and rub it between the hands in water.

Rosin compound :—One pound of washing soda is dissolved in one gallon ($\frac{1}{4}$ tin) of water in a kerosene tin and as the solution boils two pounds of powdered good quality rosin is poured into it and stirred with a stick. Boiling and stirring are continued, cold water in small quantities being added to prevent boiling over. Cooking is continued till the solution turns to clear coffee colour and stops boiling over when cooking is complete. It can be tested by putting a few drops in cold water. It should form an amber coloured solution and leave no white milky precipitate. One-fourth pound of sliced bar soap is now added and boiled till dissolved. The stock solution is now ready and will be about two and a half to three gallons on account of the additions of water. It can be kept in a closed vessel for any length of time and used when required. If stored in an open mouthed vessel evaporation may ultimately reduce it to a thick jelly.

One, two or three pints of the stock solution in a kerosene tin full of cold water forms weak, ordinary or strong solutions respectively for use. Smaller quantities of the stock solution should be taken when it thickens due to evaporation.

Longicorn beetle borers in stem :—A legless white fat grub bores tunnels inside the stem a branches and throws out wood dust through holes here and there on the sides of the affected ste or branch. This grub takes several months to grow and feeds all the time by corroding the wo and forming tunnels. The infested stems and branches may be converted into hollow tube An allied grub bores just under the bark causing extensive tunnels which are filled with woo dust and grass. The grub pupates when fullgrown and ultimately transforms into a beetle wit long antennæ or horns, from which the common name is taken (Fig. 29).

Caterpillar borer on stem :—This caterpillar (*Arbela* sp.) has the habit of forming a hole i the stem and living in it. It nibbles the surface of the bark round this hole under cover of webbing in which the pellets of its excreta are interwoven and held. This webbing attract notice. But actually damage done to the tree is not much. The caterpillar occurs only on tre mulberry. The webbings should be removed and the hole probed with a wire. The caterpilla dies if it gets pricked by the wire. If allowed to live, it turns into pupa when fullgrown and the transforms into a moth which lays eggs from which these caterpillars hatch. This caterpilla is a slow grower and it is several months before it pupates (Fig. 30).

FIG. 29—A longicorn borer beetle in mulberry stem. A bored stem, grub and beetle.

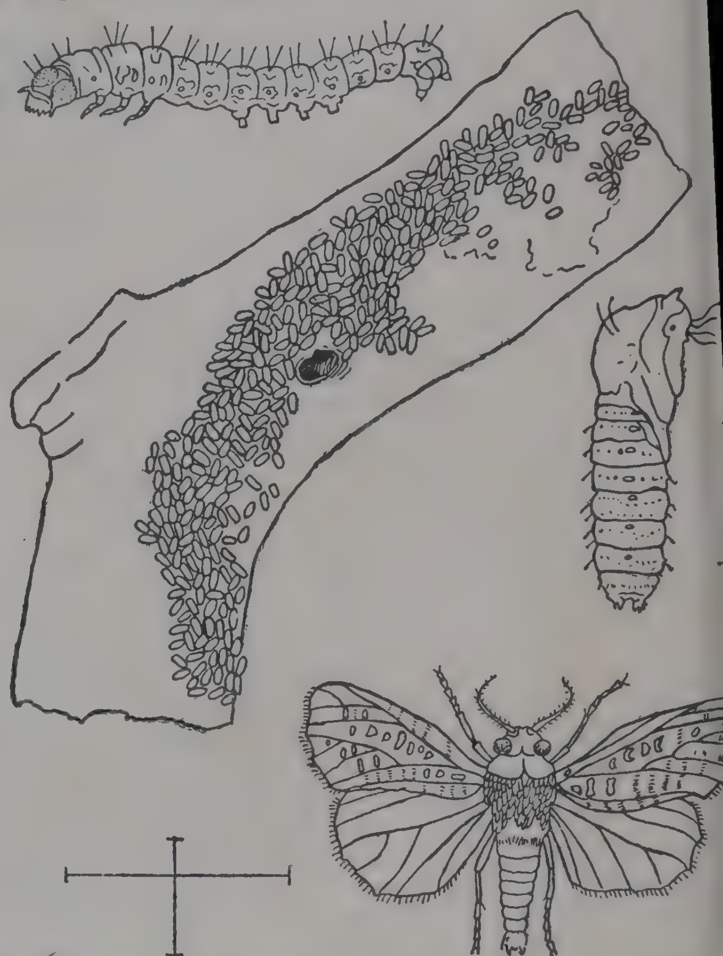


FIG. 30—Arbelid borer on stem. The caterpillar on top bores a hole in the stem, lives therein and nibbles the bark at night, covering nibbled places with pellets of excreta bound with silk. Pupa and moth.

FIG. 31—Thrips on leaf, with wings closed and open.

Thrips on leaves :—Thrips are minute insects illustrated in Fig. 31. A yellow coloured minute thrips (*Pseudodendrothrips ornatissimus* Schmutz.), looking like small yellow threadlike streaks on leaves, proved to be a serious pest attacking the leaves of new shoots growing after pruning in early winter at Mandalay. As it occurred in enormous number whole fields looked scorched. The affected leaves wilted and fell off. The pest has not been recorded so far elsewhere. Thrips can be killed off by being sprayed with soap or rosin compound solution.

Hairless caterpillar on leaves :—This caterpillar (*Glyphodes pyloalis*), rather slender, hairless and greenish yellow in colour occasionally occurs on leaves and bites hole in them. When fullgrown it turns into pupa in a fold on the leaf and ultimately into moth which lays eggs from

which these caterpillars hatch. It does not occur in large numbers and can be easily picked off with hand and crushed under foot. (Fig. 32).

Hairy caterpillars on leaves :— This hairy yellow coloured caterpillar (*Diacrisia obliqua*) has been observed to occur in large numbers on bush mulberry of which all the leaves were eaten by it. (Fig. 33). The caterpillars hatch from pearly round eggs laid in a cluster usually on the

FIG. 32—Hairless caterpillar on leaf (*Glyphodes pyloalis*). Slender green caterpillar binds and folds the leaf with strands of silk and feeds on the leaf. When fully grown it transforms into pupa and moth.

3—Hairy caterpillar f (*Diacrisa obliqua*). aid on leaf in cluster. g caterpillars nibble green substance of . Grown caterpillar, and moth.

under surfaces of leaves. Each cluster contains several hundred eggs from which tiny hairy caterpillars hatch and feed gregariously at first on the green tissue of the leaves leaving a white membrane. Such membranous leaves are easily observed by one looking at or walking through the field and they have if observed early clusters of young caterpillars on them. When the caterpillars grow they disperse and go on biting and feeding on the leaves until they are fullgrown. They then descend to the ground and form cocoons in which pellets of earth and their own hairs are woven and turn into pupæ in these cocoons and ultimately into moths which lay eggs again.

When it occurs it does so in numbers and causes a lot of damage. The practical remedy is to be on the look out, collect the leaves with egg clusters and clusters of young caterpillars and bury them under the ground.

White grubs or cockchafer grubs (*Lachnosterna* sp. and others) *on roots of seedlings and young plants* :—(Fig. 34) These grubs are met with in cowdung heaps and in the soil among roots of grasses, cereals, vegetables, etc. They hatch from eggs laid by beetles one of which is shown in this illustration. There are many kinds of such beetles which emerge in large numbers and often in swarms from the earth after the first heavy showers of rain, mate and lay eggs in the soil. The grubs which hatch from the eggs feed on the humus in the soil, cowdung and other animal droppings and on roots of grasses, juar, (*Andropogon*), sugarcane and in fact on roots of any plants growing where they happen to be. The grubs take several months to grow and go into rest and pupate and issue as beetles as described above.

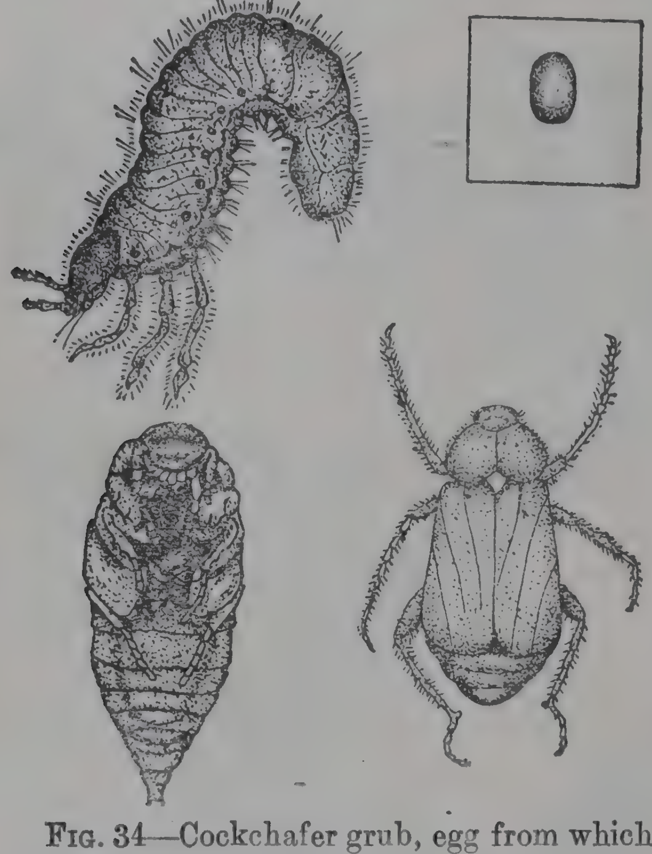


Fig. 34—Cockchafer grub, egg from which it hatches, pupa and beetle.

The grubs may come into the field with farmyard manure applied to the field. It is advisable to search and remove them before applying the manure. When grubs are observed to infect a seed bed or bed of young plants the practical remedy is to rake the soil and pick them off. They may be cut or crushed or thrown on dry hard ground where they will die or fed to fowls.

June beetles or cockchafer beetles on leaves :—Their life history is similar to what is given under white grubs. At Mandalay after the first heavy showers of rain a beetle (*Holotrichia* sp.) appeared after sunset in swarms which attacked mulberry trees as well as bushes and ate away the leaves and even the bark of the stems. They invariably attacked the taller plants first and then the shorter ones. In years characterised by light showers even though frequent or continuous there was hardly any damage. The practical remedy is to shake off the beetles clustering on the plants into buckets of water mixed with kerosene oil and then bury them in pits in a hard ground.

Weevils (*Apion* sp.) *on leaves* :—(Fig. 35). A small black weevil with rather a longish snout occurred on bush mulberry at the Berhampore Sericultural Station, Bengal in large numbers gregariously on bushes here and there and ate holes in the leaves, practically stripping the bushes affected. The occurrence however was not on any serious scale.

Fig. 35—Weevil (*Apion* sp.) on leaf.

Termites (*White ants*) :—Specially in sandy soils white ants have been observed to eat newly planted grafts and cuttings. They can be kept off by imparting smell of kerosene oil to the soil by watering it with a solution at the rate of about a pint of kerosene emulsion in a kerosene tin full of cold water. Watering may be done once or twice in the week until the plants sprout and grow a little.

Mole rats (*Cannomys castaneus* Blyth.) *on roots* :—(Fig. 36) The mole rat has a peculiar ttraction for mulberry roots which they eat underground killing off entire bushes and even airly wellgrown medium trees. Their presence in the field is indicated by mounds of earth hrown up here and there along the tunnels they burrow underground. They have the habit

FIG. 36—Mole rat.

f blocking the tunnels with earth behind them. Therefore no poisonous gas injected into the urrow can reach them. As soon as mounds of earth are observed in the field a search should e made for these rats and they should be dug out and destroyed.

PART III.

THE SILKWORM.

46. The life of the worm.

THE life history of the silkworm is shown in Fig. 1 and section 1. It is necessary to be acquainted with details of its life and habit so as to be able to rear it properly for the purpose of securing the cocoon from it.

Young worms begin to feed on leaves immediately after hatching from the eggs. After a few days they stop feeding, rest for about a day or so and then cast off their skin exactly as is done by a snake. This is called moulting. Then they feed and again moult. In this way they pass through four moults in their life before spinning the cocoon. The periods between the moults are described as ages. Thus the young worms from hatching to first moult are of the first age. The second age is from the first to the second moult. The worm therefore passes through five ages before spinning the cocoon. Inside the cocoon it moults for the fifth time at which it transforms into pupa. The worms feed for about 4 to 5 days in the first age, for about 3 to 4 days in the second and third ages, for about 4 to 5 days in the fourth age and for about 7 to 10 days in the fifth age. The ages and feeding periods vary with temperature and may be lengthened according to intensity of cold.

It is only in the worm or larval stage that the silkworm feeds. No food is taken in egg, pupa or moth stages. Proper aeration or ventilation is however required in all stages. The liquid substance (yolk) inside the eggshell changes into the embryo or tiny worm which bites its way out of the shell. In the case of univoltine worms the change or development is in abeyance for several months while in the case of multivoltine worms it takes place quickly.

Fig. 37 shows the external characters of the body of a grown-up worm. The body is marked into several segments or rings and is divided into three regions viz. head, thorax or chest and abdomen. The head bears the mouth parts on the underside and the following can be clearly seen viz. upperlip, pair of mandibles or jaws for cutting bits of leaf, a pair of antennæ and the spinneret through which the silk filament is thrown out.

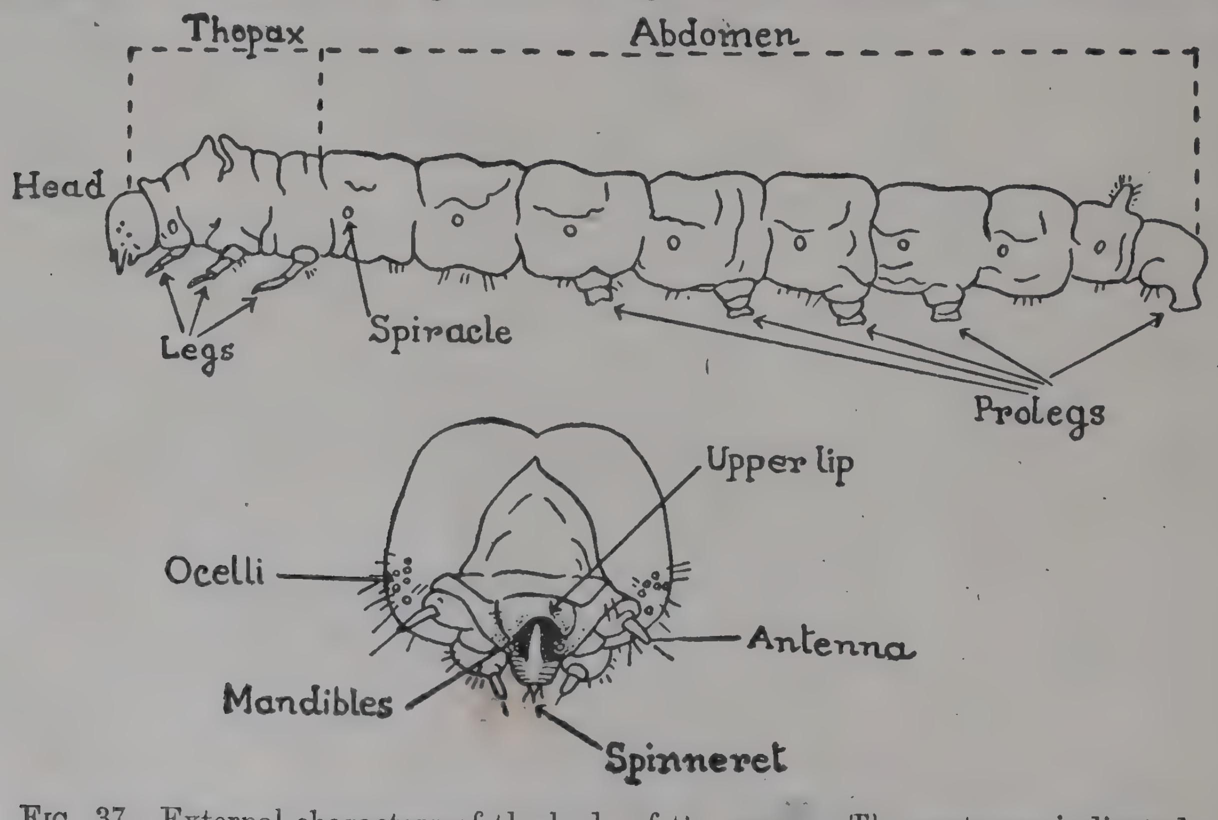


FIG. 37—External characters of the body of the worm. The parts are indicated in the illustration.

The mandibles move sideways. On each cheek there are small eyes or ocelli. The thorax bears the three pairs of legs under its three segments. The 3rd, 4th, 5th, 6th and the anal segments of the abdomen bear prolegs and it is with hooklets on the soles of the prolegs that the worm keeps its hold on the leaf or stem. The first thoracic and the first eight abdominal segments have on each side a breathing hole or spiracle and it is through these nine pairs of holes that air enters into the body and circulates through air passages or tubes and tubules running through the entire body substance. The sex of the worm can be determined by certain markings and spots on the underside of the last two segments as indicated in Fig. 38.

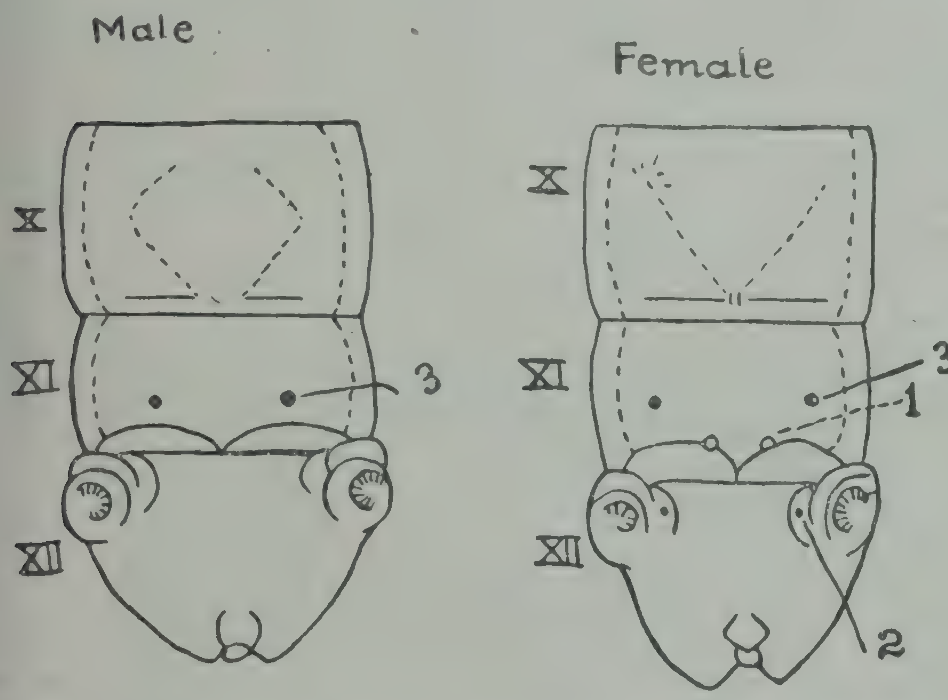


FIG. 38—Sex marks of the worm on the under-surfaces of hind segments.

Fig. 39 shows the internal anatomy of the worm. The parts to notice are the alimentary or food canal running from the head to the anal end, the tracheal system or the breathing tubes and tubules running through all parts of the body (not shown in the illustration), the dorsal vessel or heart the movement of the blood in which can be seen by looking at the back of the worm, the silk glands and the nervous system.

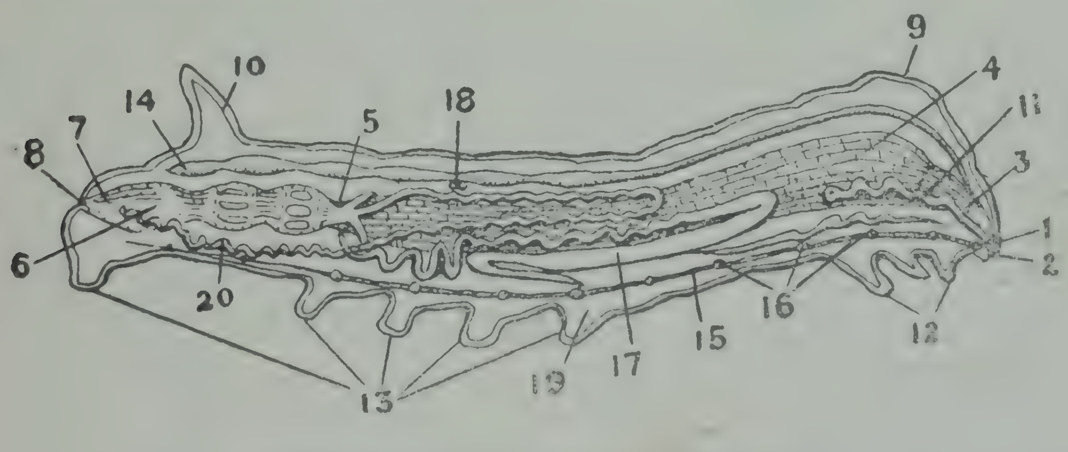


FIG. 39—Internal anatomy of the worm.

(1) Head. (2) Mouth. (3) Oesophagus. (4) Stomach. (5) Intestine. (6) Colon. (7) Rectum. (8) Anus. (9) Upper skin (cuticle) or ectoderm. (10) Lower skin (hypodermis). (11) Salivary gland. (12) Thoracic legs. (13) Pectoral legs or prolegs. (14) Dorsal vessel or heart. (15) Nerve cord. (16) Ganglions in the nerve cord. (17) Silk gland. (18) Reproductive organ. (19) Hœmocœle. (20) Malpighian tubules (excretory organs).

The external structure of the pupa indicates the crumpled mouth parts, legs and wings of the future moth. The pupa too has breathing holes on its sides.

The female moth is born with eggs in her abdomen and her only function in life is to mate with a male moth for fecundation of the eggs and then lay the eggs so that the generation may be continued. The moths though active do not require any food and in fact they have no mouth parts. They however have breathing holes on the sides of the body through which they breathe.

47. Diseases of the silkworm.

Pasteur mentioned four diseases viz. pebrine, muscardine, flacherie and grasserie which are still present and may be taken to have affected silkworms all through the period they have been under domestication and which assume epidemic forms under certain circumstances unless proper precautions are taken. In addition to these four, two others are at present recognised viz. gattine and court. The diseases may be classified as follows :—

(a) Germ diseases, caused by foreign microscopic organisms when they find access into the body of the silkworm. These are (1) pebrine, caused by a protozoon, *Nosema bombycis* and (2) muscardine, caused by a fungus, *Botrytis bassiana.*

(b) Physiological diseases caused by some disturbance in the metabolism or functioning of the internal organs of the body. These are (3) flacherie, with symptoms associated with indigestion, diarrhoea and cholera of man, (4) grasserie, which is comparable to jaundice of human beings, (5) gattine, characterised by emaciation followed by death when the body decomposes with symptoms of flacherie and (6) court, in which worms apparently healthy pupate without forming cocoon.

Pebrine.

The name is due to black spots found on the skin of affected worms, otherwise called "pepper disease", the spots resembling pepper sprinkled on the skin. This phenomenon however is not evident in India. The Bengali name *kata* means paleness in the worm. The causal agent, *Nosema bombycis,* is known to be observed to occur in some insects including the silkworm. The mature stage of this minute organism is recognisable as an oval, shiny spore through a magnification of about six hundred times under the microscope (Fig. 40). It is in this stage that it spreads the disease. When the spores are swallowed by a healthy worm they reproduce and multiply attacking the body tissues. External symptoms do not become evident until the infection is far advanced. On account of the injury to the parts connected with production of digestive juices and absorption of food the worms are starved, become pale and unequal in growth (Fig. 41). The excretory organs cannot function leading to sluggishness and further interfering with growth. Injury to the silk gland results in poor output of silk and flimsy cocoons. A badly infested worm develops into moth with scorched, crumpled wings (Fig. 42) and owing to affection of the reproductive organ, eggs of such moths are laid irregularly and may not hatch. Worms hatching from such eggs are infected and usually die.

The progeny of an infected lot is infected and a healthy lot is infected usually by eating spores falling on the food. Spores are passed out by infected worms with excreta which contaminates leaves, trays, floor of the rearing house and hands and clothes of the persons handling them. If the excreta is allowed to dry spores are carried by wind which vitiates the whole atmosphere. Spores remain infective for about three to six months and if they find access into the stomach of a worm they reproduce and multiply giving birth to fresh spores in the course of only about three to four days.

In order to guard against loss through this disease the following measures are necessary and have been practically found to be effective.

(1) To rear from examined seed in order to be sure that the lot is not infected.

(2) To keep the worms in healthy condition, i.e. to rear them in well ventilated, uninfected houses with uninfected appliances.

(3) To feed the worms with good, nourishing and sufficient food.

(4) To take precautions against dust being raised in the rearing house; the practice followed by the village rearers in some areas of applying liquefied cowdung on the mud floor is good as it lays spores if any and prevents them from flying about; the old beds and refuse from rearing trays should be handled with care and not disturbed much in the house; these precautions prevent increase of infection in case there be any worm infected in the lot under rearing.

(5) Not to rear examined and unexamined worms, if any, together.

(6) Not to use trays and appliances of others without disinfection.

(7) Not to keep rearing house refuse exposed to sun but always to cover them under earth in a pit or under dung in the dung heap, thus preventing spores being carried about and spread by wind.

(8) Not to use fresh rearing house refuse as manure in the fields.

(9) After rearing is over the house should be thoroughly cleaned and the appliances washed, cleaned and dried in hot sun. If there be an epidemic of the disease disinfection of the house and the appliances should be carried out in addition to cleaning in order to kill off spores present. This is specially necessary in the case of multivoltine worms as successive rearings follow after short intervals.

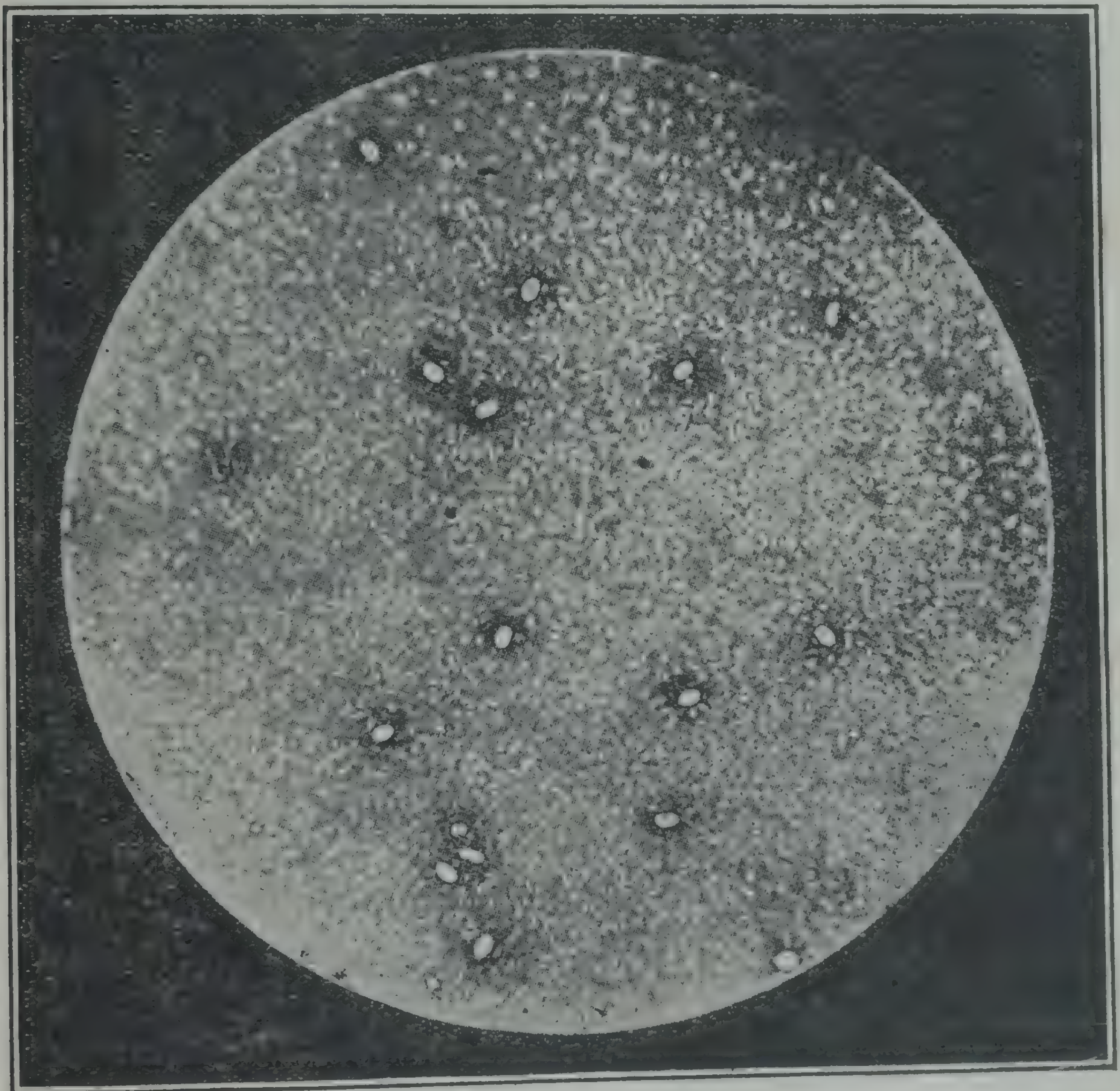


FIG. 40—Pebrine spores (after Jameson).

Fig. 41—Unequal growth of pebrine infested worms (after Jameson).

Fig. 42—Moth with crumpled wings developed from pebrine infested worm (after Jameson).

If the worms are fed, looked after and maintained in vigour they are able to overcome the evil effects of light pebrine infection which can further be prevented from assuming serious proportions in the course of rearing if precautions as above are taken. Pebrine if present increases in successive generations. Therefore it is always unsafe to do rearing from unexamined eggs. It is always advisable to take eggs from grainages after proper examination.

Muscardine.

Common names, Calcino in Italian and *Chuna-kati* (i.e. stick of lime), in Bengali express well the worm dying of this disease.

The causal agent is a fungus, *Botrytis bassiana*, which attacks other caterpillars besides silkworms and with which *Botrytis tenella* and other fungi have been recorded to occur. The fungus when mature bears minute globular spores which cause the disease when falling on the body of the worm and germinating under humid conditions. Each spore gives rise to a delicate filament which penetrates into the body of the worm and throws out branches rapidly which ramify through and draw nourishment from the body tissues, the process resulting in the death of the worm. When highly magnified under the microscope the developed fungus looks like what is shown in Figure 43. Immediately afterwards the fungus pushes its spore bearing branches through the skin which cover the body with a felt like coating of filaments bearing countless spores. The dead worm becomes stiff and mummified and spores scatter from its body. These spores are believed to live for about three years and when they fall on suitable hosts undergo full cycle of development under humid conditions in the course of about three or four days. The disease kills off all worms under rearing in the course of only a few days. After this the spores invisible to the eye, live in the house, its surroundings and in the soil in the fields. They can be killed only by a disinfectant like bleaching powder or formalin solution. This disease had all along been considered as a terrible scourge by the silkworm rearers in Bengal. With

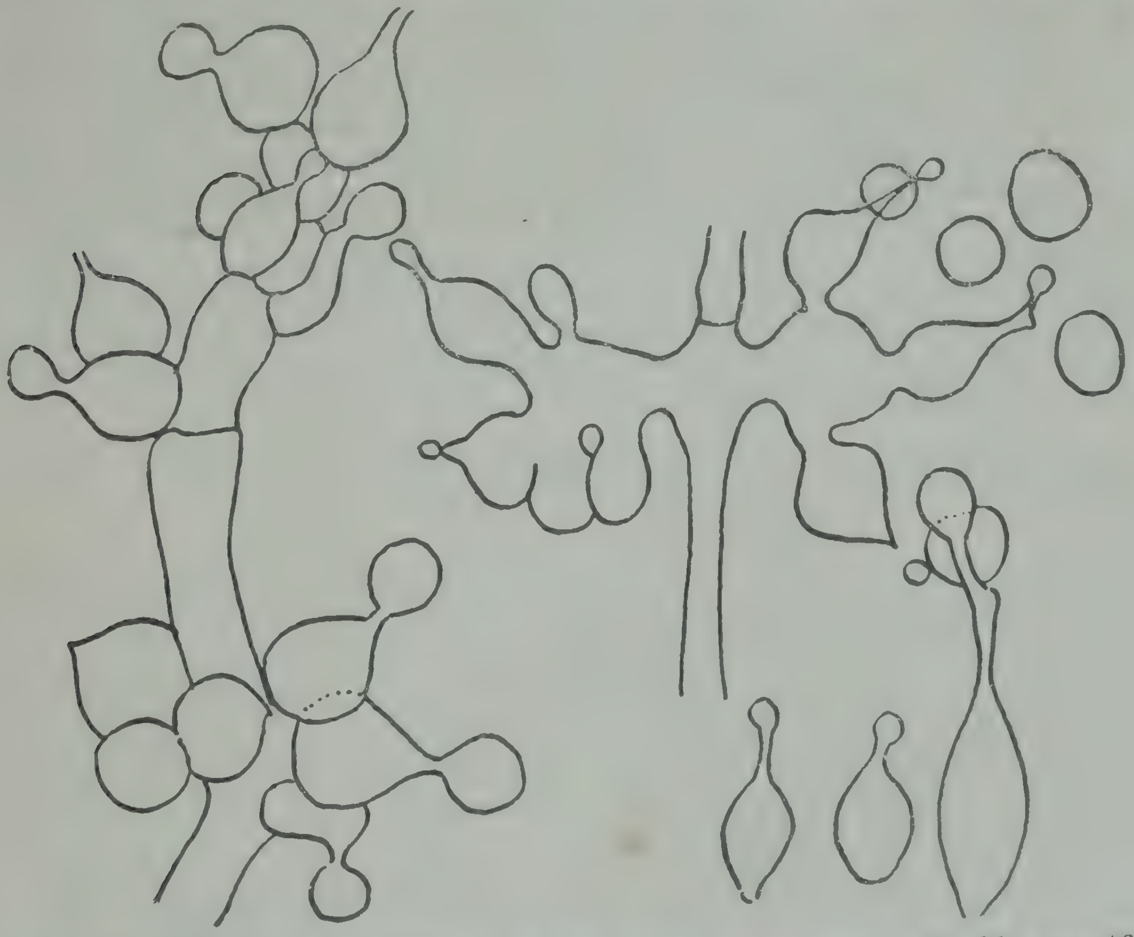


Fig. 43—Fungus causing muscardine, as seen under the microscope, highly magnified.

liberal use of bleaching powder solution to wash rearing houses, trays and appliances and spray rearing house refuse since 1935 the disease has been completely kept under control and so well as to become rare at present. When the disease occurs if careful watch is kept on the worms under rearing and the disease detected at start the worms can be saved. If any worm develops muscardine it should be slowly and carefully picked off and placed in disinfectant solution. The worms in the tray should be transferred to a clean tray with the help of a net and the tray with the refuse in it soaked with disinfectant water. Then all the trays under rearing should be similarly treated. Stirring of the untreated refuse should be avoided. Such cleaning should be continued till the fear of an outbreak disappears. Burning a small quantity of sulphur and maintaining light sulphur fumes in the rearing house at the rate of an ounce of sulphur per 100 cubic yards of space in addition to eliminating diseased worms as above is of help in checking the progress of the disease.

Flacherie.

The Bengali name, *Kalshira* refers to the black appearance of worms dying of this disease. The disease generally occurs in grown-up worms which die mostly just before spinning cocoons. They show characteristic symptoms. At first they lose appetite and do not eat well and look rather sickly losing the natural shining healthy appearance of the skin. The pellets of excreta become soft and stick to one another. The moults may not be shed properly but pieces of them may remain encircling the body. With the progress of the disease the worms become sluggish and they vomit a brownish liquid. The faeces are soft, almost liquid and soil the anus. Finally the worms become motionless, their body becomes soft and discoloured becoming black, at first in the middle and then wholly putrefying and falling into a liquid state and emitting a bad sickly odour, not associated with any other disease. The diseased and dead worms show a number of bacteria in their gut. The French sericulturists in the beginning recognised two, one causing fermentation (*Streptococcus bombycis* forming chains of spores) and the other causing putrefaction (*Bacillus bombycis* showing as rods), as chiefly responsible and as both hereditary and contagious and hence the attempt at their elimination under microscopic examination (Fig. 44). Later investigators Italian, Japanese and Dr. Paillot the present authority in France and also Dr. Pringle Jameson who worked with Indian multivoltine worms unlike the others who worked with univoltine worms, hold the view that none of the bacteria found in the worms affected by this disease can be considered to be its exciting cause. These bacteria are found in air, on mulberry leaves and even in the gut of healthy worms. Dr. Jameson's experiments by actually feeding worms with them went to confirm this view. The present conclusions are that the disease is caused by some disturbance in the worm's metabolism or normal physiological functions and the bacteria flourish in the already diseased gut and they therefore are not a cause but a consequence of the disease. The disease is not considered infectious.

One condition which is observed to bring about the diseased state of health leading to flacherie is high temperature combined with high humidity and want of proper ventilation.

The diseased state of the worms is indicated by lessened alkalinity of the gut and thickening of its inner membrane. Under the conditions the bacteria observed in association with this disease multiply. Jameson found that lessened alkalinity was brought about by high temperature. The disease in the case of multivoltine worms is commonly ascribed among other causes to eggs having been affected by exposure to highly fluctuating temperature. Recent investigations by N. N. Roy, Agri-biochemist, of actual outbreaks of flacherie in Bengal have shown that it is intimately connected with food. He has invariably found that the leaves in such cases had unbalanced constituents. In one case it was excess of iron (Proc. First All-India Sericultural Conference, p. 133). The rearers in Bengal ascribe occasional occurrence of this disease to what they call *bishalpata* i.e. posion in leaf. The *bishalpata* condition occurs in the rainy season when leaves are affected by a rust. Roy associated this with deficiency of potash and low protein and sugar contents in the leaves

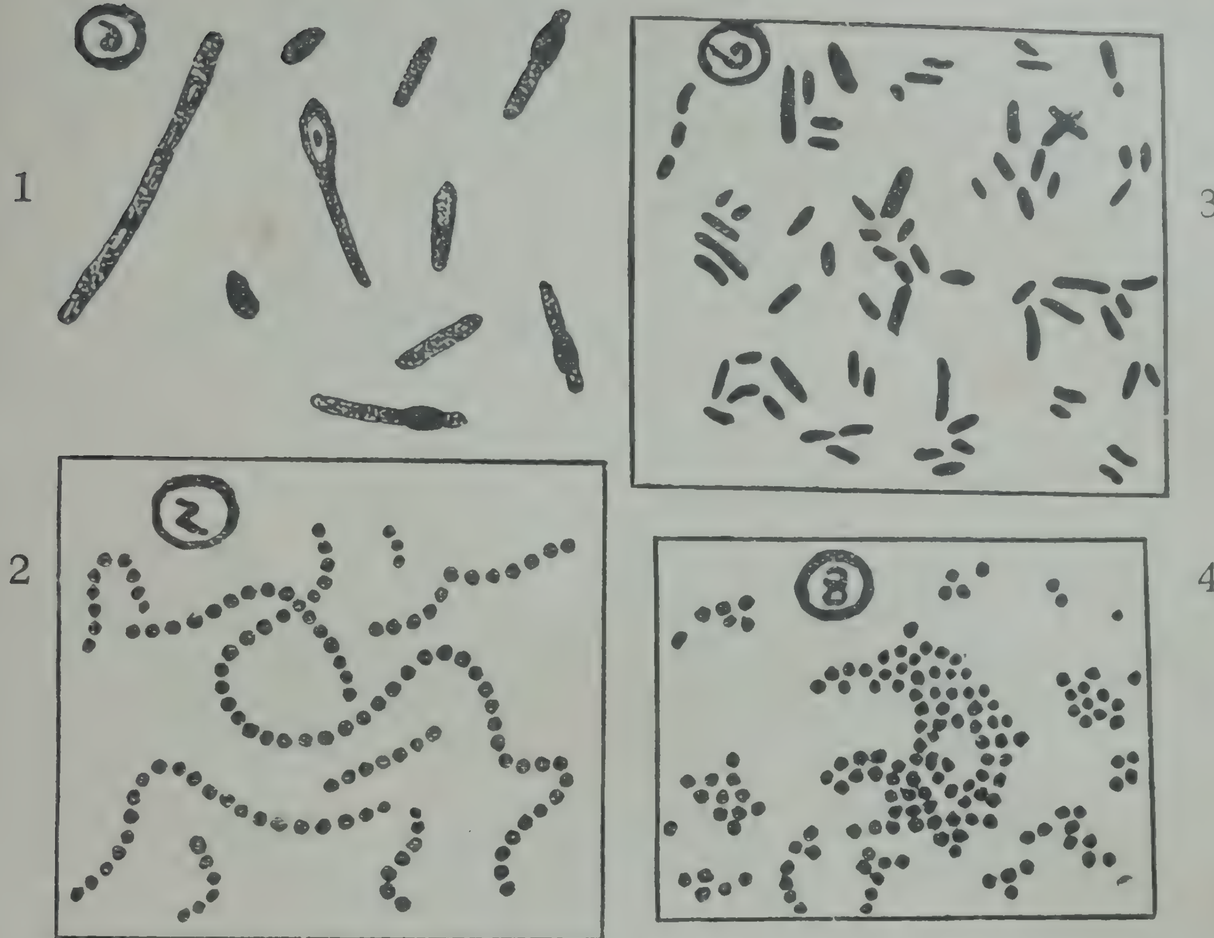


Fig. 44—Some Bacteria associated with Flacherie disease—(1) Bacillus bombycis (2) Streptococcus bombycis (3) Bacterium coli (4) Staphylococcus.

ultimately due to deficiency of potash in the soil (Proc. 1st All-India Sericultural Conference, p. 123). Another *bishalpata* condition arises when after root pruning about September-October the fresh shoots of bush mulberry in Bengal are overtaken by a shower of rain. Another experience of Bengal rearers is that light showers after drought cause havoc among worms. Complete absence of rain or heavy showers after a long drought are not serious. Light showers under such condition have been observed by Roy to upset the physiological balance of the nitrogen, phosphate and potash contents of the soil causing poverty of soluble sugar and potash in the mulberry leaves grown on it (Papers presented for the 3rd All-India Sericultural Conference, p. 29). He advised increasing the potash content of the soil by adding partially decomposed straw to it.

Grasserie.

Bengali name *Rasa* i.e. due to excess of moisture in leaves.

Worms affected by this disease show very easily distinguished symptoms, becoming bloated in appearance, the skin becoming somewhat shiny and yellowish in colour and the blood becoming turbid like pus instead of being clear as in ordinary worms and when examined under the microscope it is found to be full of minute polyhedral crystalloids (Fig. 45). These crystalloids are also found in the different organs of the body. They are brittle and can be easily crushed by a little pressure on the coverslip on the slide. They are the results of the diseased condition of the blood and tissues and are found also in worms suffering from pebrine and flacherie and attack of the parasitic fly. Affected worms die before spinning. The disease is chiefly associated with tender leaf fed to the worms after they have eaten mature leaf for some time or if after a period of dry weather showers of rain increase the watery contents of the leaves suddenly. It can be brought about by closing the spiracles i.e. the breathing holes of the worm, clearly indicating its connection with

physiological disturbance in the body due to want of proper ventilation and to vitiated air. Although the disease usually occurs in grown-up worms in the fifth age, on one occasion in the writer's experience the whole lot of worms mostly in the third age were affected in a room at Maymyo, a hill station, due to mistake in shutting off ventilation. That the disease

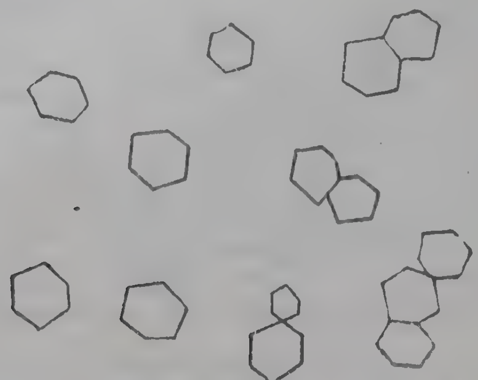


FIG. 45—Polyhedral crystalloids of grasserie disease.

is also connected with high temperature will be evident from the common experience that univoltine worms reared in winter in the plains suffer from it when there is rise in temperature. The disease is also connected with the quality of food. The fixed hybrid Nistid and Nismo worms first introduced in Bengal generally suffered from this disease on account of the bush mulberry with which they had to be fed. It is the common experience that in the plains univoltine worms can resist the disease to a great extent when fed with leaves of tree mulberry.

No causal agent is known for this disease which like flacherie is evidently due to disturbance in metabolism or normal physiological functions of the body brought about in various ways. Bacteria usually associated with flacherie are also found in worms suffering from this disease. As is now generally accepted in the case of flacherie none of these bacteria can be considered to cause this disease. M. R. Das Gupta, Protozoologist of the Bengal Sericultural Department suspects a virus to be the cause, which is very unlikely like the bacteria. The late N. N. Roy, Agri-biochemist of the department found a substance in the tender leaves of mulberry in some cases which even in minute doses is known to act as a virulent poison and which he found associated with polyhedral crystalloids very common in this disease. Unfortunately he died before concluding his experiments. In this disease too the food plays the principal part. The precautions to be taken until the real cause is understood are :—

1. Proper ventilation in the rearing house.

2. Avoidance of tender leaves in the case of grown-up worms. In the case of bush mulberry grown in Bengal, Mysore and Madras the practice of breaking off tender tops of the plants from which leaves are intended to be fed to growing worms and thus allowing the leaves to mature without further growth of the shoot, is practically found to be effective. The leaves of trees and high bush are for the same reason observed to enable the worm to resist the disease.

3. Feeding young worms with tender leaves and giving them gradually maturer leaves as they grow.

Gattine.

The Bengali names *salpha, hansa* or *tatka* are indicative of the translucent appearance of the body of the worms affected and evidently meaning what French sericulturists express by "lucettes" or "clairetts". The characteristic symptom is emaciation and retarded growth and translucent appearance of the worm due to almost complete absence of food in the gut and the skin becomes semitransparent. Worms become emaciated and slowly die decomposing after death as in flacherie. Bacteria are found in the gut as in flacherie. This disease commonly appears in early ages unlike flacherie which generally affects grown-up worms. This disease too is primarily due to metabolic disturbance.

Court.

The common Bengali names *lali*, *rangi* (i.e. red) and *kurkutte* (i.e. stunted) refer to the pupa which in this case is formed without cocoon and which is much shorter than the worms. As no cocoons are obtained the rearing attempted is lost. N. N. Roy, Agri-biochemist, had a chance of investigating this disease which occurred in Malda in 1940, February, and his conclusions are published in the report of the second All-India Sericultural Conference, p. 69 under the caption "An instance of under-development of worm due to deficiency of certain elements in the food". As long ago as 1899 N. G. Mukherjee recorded this disease as occurring in February and March owing to the leaf at the season being "wanting in nutrient properties" but said that "when any considerable loss takes place from this cause it should be put down to latent pebrine". Roy found that the worms were apparently healthy and free from any bacterial or protozoal disease but did not produce silk. He found that the worms were not fully developed and remained as far as growth was concerned in a state attained in the fourth age of normal worms of the same race. He kept under observation the plot of mulberry from which the worms had been fed. A month later the leaves from a part of the plot left helped worms to develop normally. At the time when the leaves proved deficient they had a high protein content, very low sugar content, sugar protein ratio very low and phosphate and potash contents very low, all pointing to their immaturity. The soil contained a large percentage of nitrate-nitrogen due to the manure used and this coupled with deficiency of phosphates and helped by sudden rainfall led to large absorption of nitrate-nitrogen by the leaves and deficient formation of sugar in them. The leaves being immature and abnormally deficient in sugar did not provide sufficient nutrition to the worms. In this connection mention may be made of death of worms ascribed in this locality to *bishalpata* i.e. poisonous leaf. When a shower of rain overtakes young mulberry after root pruning given about September-October, the leaves are believed to become poisonous and they actually cause death of worms with symptoms of flacherie. The court disease is therefore due to metabolic disturbance caused by deficiency in food.

48. Research necessary in connection with diseases.

The germ diseases, pebrine and muscardine are understood and can be controlled with efficient measures and it is a question of organisation of measures to keep them under check. It is the physiological diseases, flacherie, grasserie, gattine and court, which are not understood and which require investigation. As will be evident from the descriptions given above of our present knowledge about them, they are primarily due to disturbances in metabolism or normal physiological functions of the organs of the body of the worm brought about partly by climatic abnormalities but principally by deficiencies or excess of some elements in the food. Organisms met with in association with these diseases such as bacteria in flacherie or polyhedral bodies in grasserie follow in the wake of the diseased condition brought about by the functional derangement. The lines on which research is necessary and is likely to give fruitful results are study of the physiological behaviour of the worm in conjunction with study of the food i.e. mulberry leaf, its constituents and nutrient properties and connection of these with physiological normality or derangement of the worms and also of the soil on which the mulberry is grown. Effects of variations in climatic conditions on the worm should of course be taken note of at the same time and also the occurrence of organisms like bacteria, protozoa and fungi and whether these have any toxic effect on the worm.

49. Precautionary measures necessary in the production of seed in order to avert risks due to diseases in the rearing of silkworm.

Pebrine is heritable, while the other diseases are not. The parent stock must therefore be kept free from it and whether it is free or not can only be determined by microscopic examination. As the worms even from pebrine free eggs can imbibe the disease in the course of their life through contamination the practice is to keep the parent worms under rearing

under watch. If pebrine occurs it can be detected beforehand before undertaking the trouble and expense of moth examination. Observation of parent worms under rearing is especially necessary to guard against the physiological diseases, flacherie, gattine and grasserie. Although these diseases are not heritable the experience is that when any lot of worms suffers badly from flacherie or grasserie its progeny has a tendency to develop such diseases. Therefore in practice if in any lot more than ten per cent of worms die of them it is considered to be unfit for use for seed purposes. Microscopic examination is not of help in the case of these diseases and observation of worms under rearing is the only preventive that can be taken. Examination and observation necessary and their methods are detailed below :—

A. For the parent stock :—

(1) Mother moths of multivoltine worms are isolated by being covered with tin or other funnels on sheets of paper on a tray. This facilitates the work as moths require to be examined within about a week before their eggs hatch. The body of the moth is placed in a mortar and crushed well with pestle with a few drops of water. A drop of the preparation is placed on a glass slide and covered with a small cover slip and examined under the microscope for detecting presence of pebrine spores. Instead of plain water 1 to 2 per cent potassium hydroxide solution in water can be used. It dissolves fat bodies and helps detection of pebrine spores. In order to avoid mess the wings of the moths may be rejected and only the body crushed and examined. Eggs of moths showing pebrine are rejected (Fig. 46).

(2) Eggs are examined by taking 4 or 5 eggs from a laying, placing them on a slide with a drop of water, placing another slide on top and crushing the eggs with pressure on the slides between fingers. The contents of the eggs get diluted in water and flow out. A

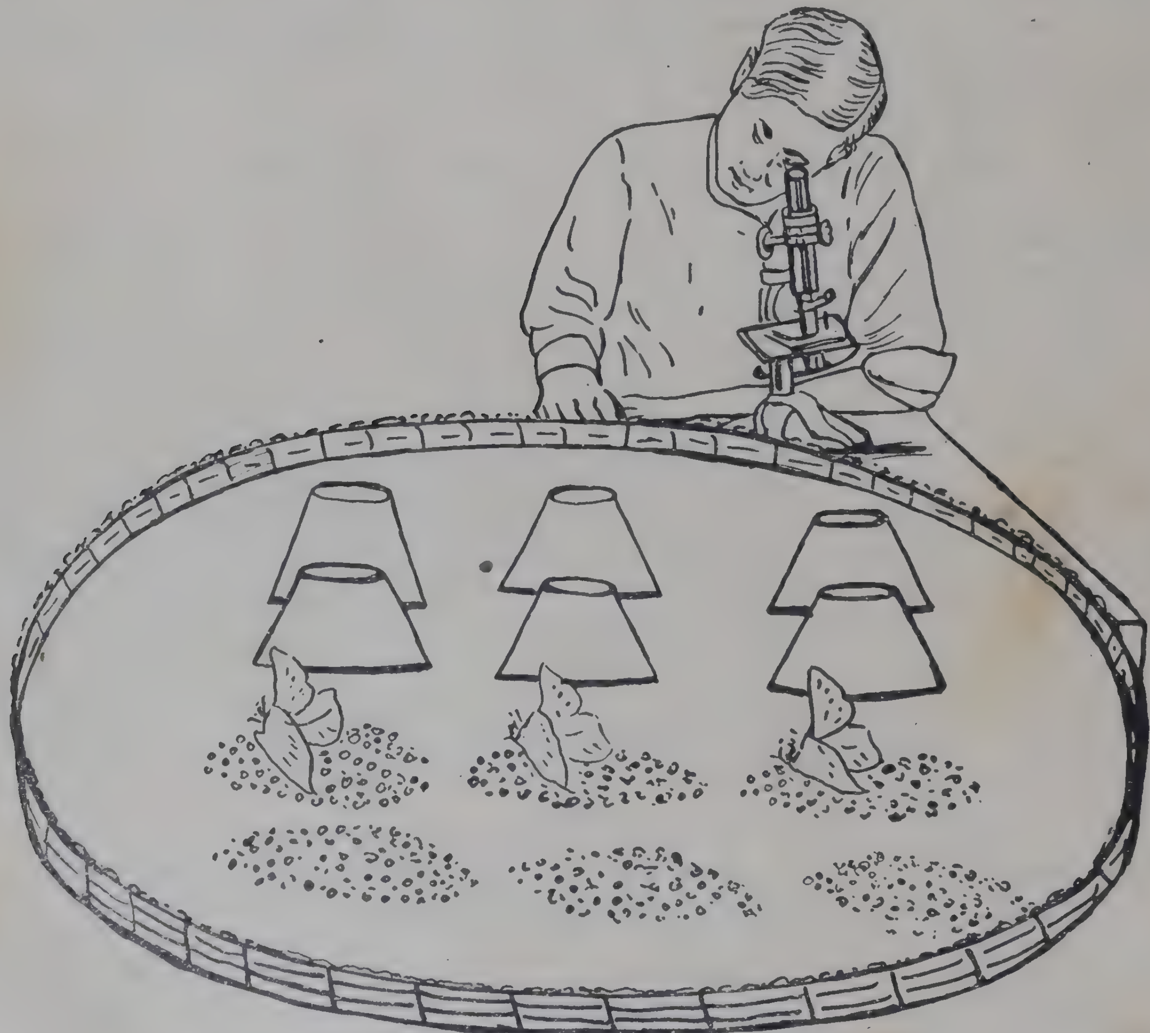


FIG. 46—Examination of moths isolated under tin funnels.

drop is examined on slide with a cover glass for detection of pebrine spores. The laying showing pebrine spores is rejected.

(3) Worms under rearing are observed and if on actual count of sick, unhealthy and diseased worms more than ten per cent are found to be affected the lot should not be used for taking seed for rearing. For pebrine a small piece of the body or silk gland of fourth and fifth age worms should be crushed and examined. At least five should be examined for each age.

(4) For examining pupa for pebrine it should be cut open and the gut should be removed and examined. At least five should be examined at random. Lots showing pebrine should not be used as parent stock.

B. For lots to be reared by general rearers for cocoon production for reeling purposes.

If the parent stock is absolutely free from pebrine it is enough if two, three or four moths are crushed together and examined. Parts of their body may be taken. If pebrine is found the safest course is to examine them separately and the lot may be passed for rearing even when upto one per cent of the moths are affected, only the layings of affected moths being rejected.

50. Enemies of the worms.

The parasitic fly (*Trycoliga bombycis*) Fig. 47:—This large fly when it finds access to silkworms lays white oval eggs on their body. The eggs are fairly large and can be seen by the naked eye. Within two days a maggot hatches out of the egg and at once penetrates into the body of the worm and feeds on the body substance. The worm shows a black mark at the spot. The maggot grows to full size within about a week. By that time the worm generally forms its cocoons and turns into pupa. The full-grown fly maggot makes its way out of the pupa and also out of the cocoon, drops on the floor and gets into the soil, contracts its body and turns into a dark brown seed-like pupa. If the maggot happens to fall on the tray or on a masonry or hard floor it pupates openly there. The adult fly develops in the pupa and issues out of the pupa case by pushing open one end like a lid in the course of about one to one-and-a half weeks. Each fly is capable of laying about 300 eggs and attacking

Fig. 47—Life history of the parasitic fly (*Trycoliga bombycis*). Two eggs laid on the body of the worm. Above from left grown-up maggot of the fly, pupa and the fly.

upto the same number of worms. Cocoons pierced by the maggot do not reel and can be utilised in the same way as pierçed cocoons. Cocoons spun by worms attacked by the maggot are necessarily of poor quality. This fly pest occurs only in Bengal, Assam and Burma. Seed cocoons are better not introduced from this area into other places. In Bengal itself it does not occur in Bankura and Midnapore districts. The only means of protection against the fly is to fit doors and windows of the rearing house with wire-gauze in order to prevent its entrance. In specially built houses fly rooms are kept. If a fly gets access into this room it is killed before the door of the rearing house is opened. Ordinary rearers hang bamboo blinds (chiks) in the doors and windows. When it is necessary to open the door one swings a broom or something to keep the fly away before the chik is raised. It is however practically impossible to prevent the fly wholly and generally some infestation takes place. This is why Bengal rearers object to continuous rearing and all in an area do their rearing at the same time or *bund* as it is called. The fly does not get hosts in the intervals between the bunds and is thus prevented from multiplying. Ants, lizards, rats, birds, etc. are other enemies which when they get access to the eggs, worms and cocoons attack them and precautions have to be taken against them.

51. Races of worms at present reared.

Important facts about the worms reared for securing cocoons in different places have been given in section 13. The races which are actually reared in India are indicated below.

Kashmir, Jammu and the Punjab:—Univoltine races (*Bomybx mori*) producing yellow cocoons and silk mainly, with a smaller proportion of white cocoons.

Mysore and Madras:—1. The local multivoltine *Mysore* race (*Bombyx meridionalis*) producing white cocoons and silk with a slightly greenish tinge.

2. First generation F_1 cross breed worms produced by crossing *Mysore* race females with males of foreign Japanese and Chinese races. They also produce similar types of cocoons as the above.

Bengal :— I. Old indigenous multivoltine.

1. *Nistari*—(*Bombyx croesi*, Hutton). It is reared in the hot weather and the rains and produces golden yellow cocoons and silk. It is also described as *Nistri* or *Madrassi*. This latter name has the following history. Dr. James Anderson, Physician General at Madras succeeded in acclimatising this worm in Madras in 1770 (see account in Watt's Commercial Products of India, p. 1018) and when conveyed back to Bengal it continued to be styled *Madrassi* i.e. from Madras. Several forms of this worm used to be recognised in the past, such as soonamooky, Madrassi, cramee. At present only *Nistari* is recognised and the alternative name Madrassi is going out of fashion.

II. Fixed multivoltine hybrids recently introduced.

2. *Nistid* (*Bombyx nistid*, Ghosh)
   (a) Yellow.
   (b) White.

3. *Nismo* (*Bombyx nismo*, Ghosh)
   (a) Yellow.
   (b) White.

Both these races produce both yellow and white cocoons and silk, the white silk having a slightly greenish tinge like that of the *Mysore* race. These worms are reared from about September to June. They do not do so well when it is either very hot or in the rainy months. These races are described by some rearers as boropolu (i.e. large worms) on account of the bigger size of the worms and cocoons.

III. Still reared on a small scale.

4. *Chotopolu or deshipolu* i.e. indigenous as opposed to Madrassi polu (*Bombyx fortunatus*, Hutton)—This multivoltine race producing yellow cocoons used to be reared

in the cold weather but has been practically wholly replaced by Nistid and Nismo races within a very short period.

5. *Barapalu* or *Boropolu* (*Bombyx textor*, Hutton), a univoltine race producing white cocoons and reared only once in spring has however been practically wholly replaced by Nistid and Nismo.

6. *Sina* or *Cheena* polu (*Bombyx sinensis*, Hutton) an old indigenous multivoltine race, producing yellow, white and greenish white cocoons, still persists in the villages of Midnapur district where it is popularly called white *Chotopolu* or *bulu* polu, the worms producing greenish white coocons.

Burma and Assam :—

1. Multivoltine worms, similar to Bengal *Nistari* and *Chotopolu* worms. The Burma worm was described as *Bombyx arracanensis* Hutton.

2. The fixed multivoltine hybrids, *Nistid* and *Nismo* which were produced in Burma must be existing there, though the occupation by Japan stopped the work of the sericultural department in that province.

PART IV.

REARING OF THE WORM.

52. Appliances in use for rearing.

In Kashmir and Jammu no trays are used. The worms are kept and fed on the floor of the house and in order to have greater accommodation some sort of a shelf may be improvised with planks and mats placed horizontally on supports. As rearing is done only once in spring not much inconvenience is felt. In areas rearing multivoltine worms for several times in the year trays are necessary.

Trays and shelves :—As regards appliances in use for rearing they are very well systematised in Bengal. Sixteen trays are arranged one above the other in a shelf formed by tying cross pieces horizontally on four posts pitched on the floor of the rearing house (Fig. 48). The illustration shows nine trays on the nine tiers of the shelf, the upper tiers being empty. Arrangement of shelves and trays in this manner is economical and at the same time convenient. Sixteen trays arranged on a shelf like this are known as a *ghara*. The extent of rearing is described as so many *gharas* and the yield of rearing as so many seers (seer=80 tolas ; a tola=wt. of a silver rupee=180 grains troy) per *ghara*. The trays in use are bamboo ones (Fig. 56) either round with a raised edge 3½ cubits or 5½ feet in diameter

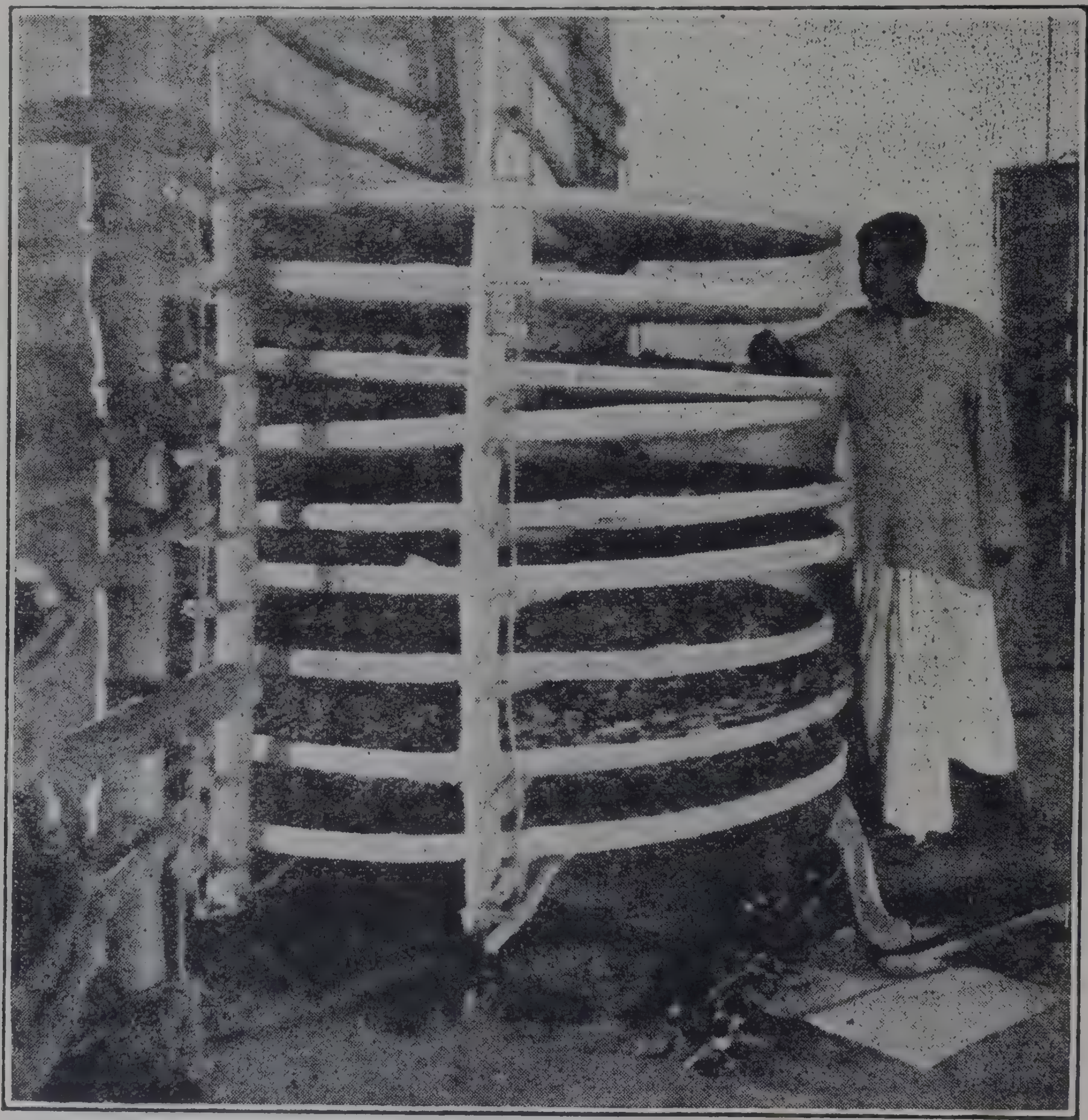


Fig. 48—*Ghara* or shelf for trays. Worms under rearing on trays arranged on the shelf.

or oblong $3\frac{3}{4}$ cubits (5′-8″) long and $2\frac{3}{4}$ cubits (4′-2″) broad. On round trays in Murshidabad district about 40 kahon (a kahon=1,280) hybrid and about 50 to 60 kahon Nistari and Chotopolu cocoons are reared. On oblong trays in Malda district about 30 kahon hybrid and about 40 to 50 kahon Nistari and Chotopolu cocoons are reared. More worms are accommodated on the trays in the cold weather. In Mysore trays are usually round and they too are arranged on shelves but not so many together as in Bengal. Here the extent of a rearing is described as so many trays and the yield as so much per tray. Although trays are usually made with bamboo matting, any materials can be used such as reeds. Some small trays for keeping young worms are better arranged for young worms as they are are very handy.

In Japan paddy straw is stringed in the form of *chiks* (blinds) about 3 ft.×2 ft. to form a sort of a mat which is spread on a bamboo frame of the same size, and this is used as a rearing tray. The mats are rolled up and stored away when not in use. In some places bamboo trays are also in use.

Mounting tray, spinning tray or chandraki (called *chandrike* in Mysore) :—Ripe worms require some support or corner to which they can fix the framework of the cocoon they build. The *chandraki* or spinning tray illustrated in Figs. 49 and 50 is very convenient for the purpose. Thin strips of bamboo are woven into a tape about $1\frac{1}{2}$ in. wide and

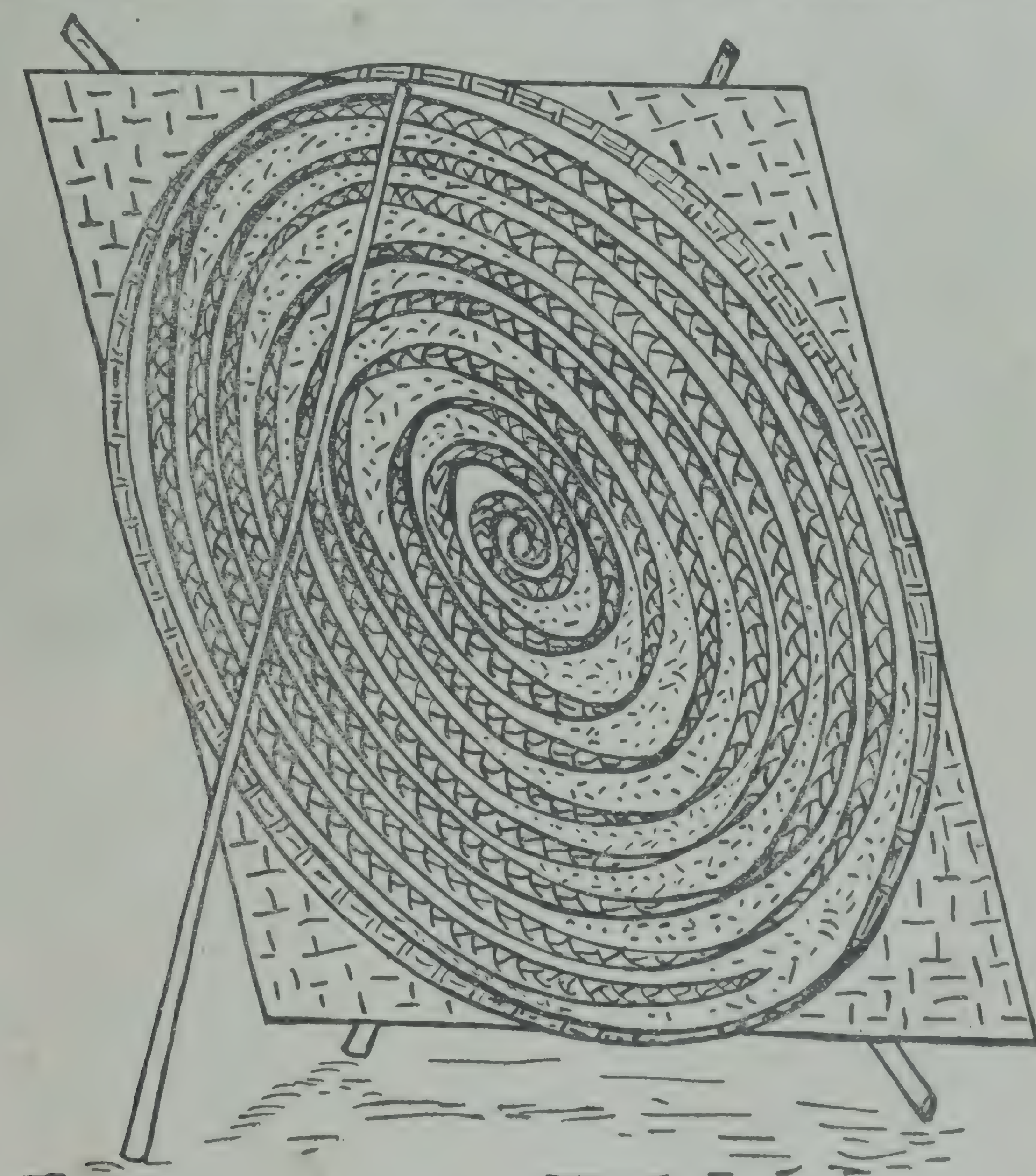


FIG. 49—Spinning tray.

this tape is tied spirally on its edge on a rather open meshed mat, the distance between th coils being about $1\frac{1}{2}$ inch. Ripe worms placed between the coils immediately get suppor for the cocoons and spin them very comfortably. Fig. 50 shows how cocoons have bee spun on a *chandraki*.

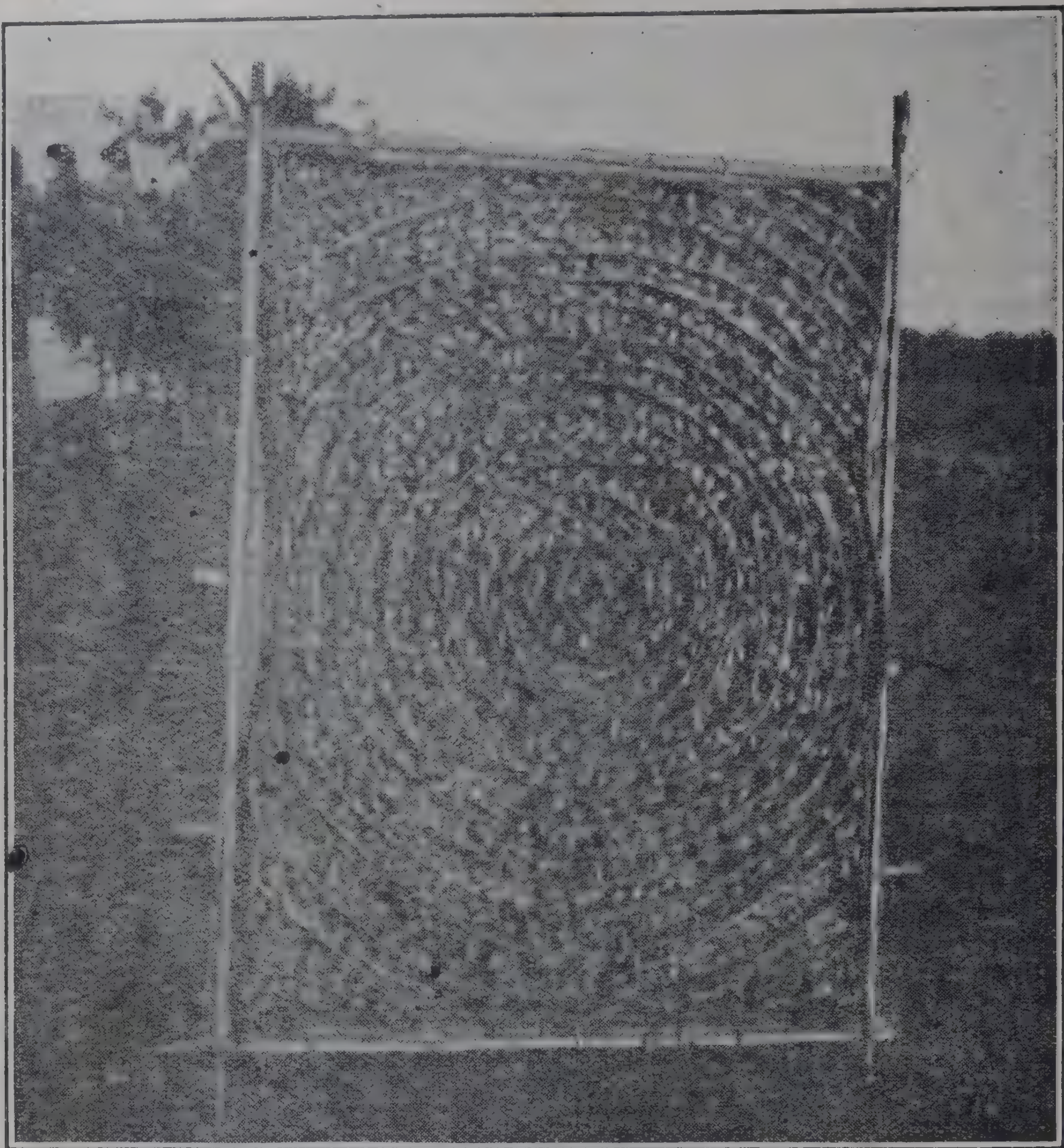


Fig. 50—Spinning tray on which cocoons have been spun.

Chandrakis are in use in Bengal, Mysore, Madras and other places. In Kashmir and Jammu and also in the Punjab no *chandraki* is used for the univoltine worms reared here. Some brush wood or dry sticks are placed round the rearing places. The ripe worms crawl on to them and spin cocoons between the twigs. In Japan paddy straw is folded with the help of a machine in the form of M and placed on trays with the arms standing vertically. The worms spin cocoons in between the folds.

Knife and bonti :—A sharp, straight-edged knife may be used for cutting leaves for young worms into strips. Several leaves are rolled together lengthwise, placed on a plank or block of wood and cut with the knife. A sharp *bonti* (Fig. 51) is preferable. In this case the roll of leaves is held between the hands and cut into strips. Leaves when large are also better cut into pieces for supply to grown-up worms. This is a universal practice in Japan.

Nets for transferring worms from tray to tray :—When worms are fed on trays it is necessary to transfer them to other trays when old trays get dirty on account of accumulation of excreta and rejected leaves. The rearers generally roll up the upper layer of leaves

with the worms and spread out the roll on a new tray. This undoubtedly causes some harm to the worms. When branches bearing leaves are supplied, these branches with the worms clinging to them are transferred to other trays. This however takes a lot of time. Use of nets (Fig. 52) with meshes through which a finger can pass is very convenient. The

FIG. 51—*Bonti* for chopping leaves.

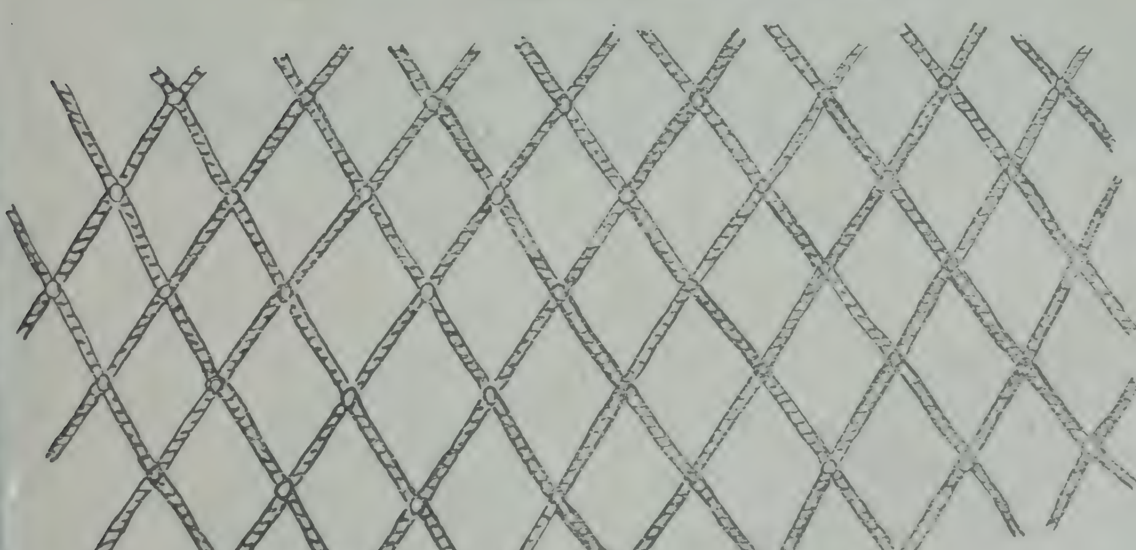


FIG. 52—Net.

net is spread on the tray to be cleaned and fresh leaves or branches bearing leaves placed on top. The worms crawl through the net on to the fresh leaves. The net with the leaves and worms can now be easily transferred to another tray (Fig. 53). In this manner many trays can be cleaned quickly. For each tray two nets are required. One has to be left with the worms. A second is necessary for the next transfer.

When worms are fed with plucked leaves transferring can be done with the help of dry paddy husks. The husks are spread over the entire tray covering the worms which soon crawl on to the top of the layer of husks. The husks with the worms are now pushed with the hand to a fresh tray. Paddy husks are in use in Japan.

FIG. 53—Transferring worms from one tray to another with the help of a net.

53. Rearing house.

When the worms can be accommodated in trays on one or two shelves rearing is frequently done in Bengal in a corner or side of the dwelling house. For larger rearing separate rearing houses are provided. Prevalence of the parasitic fly here renders it imperative that the worms should be in a house ingress of the fly into which can be prevented. Where the parasitic fly is not present, for instance in Mysore rearing is done even in open verandahs. In Kashmir and Jammu rearing is done in dwelling houses. In

France and Italy rearing is carried out in houses. In Japan although rearing is usually done in houses, climatic conditions and absence of any parasitic fly allow of rearing being done sometimes altogether in open places as long as shade is available for instance under a tree.

As regards the construction of rearing houses it is necessary to see to the arrangements for proper ventilation. Also in places like the plains of Bengal where sudden rise in temperature during a rearing may prove fatal sufficient ventilation is essential. Even in cold places change of air in the rearing room keeps the worms in health. Therefore ventilation is looked after in all places. Another point to attend to in places like the plains of Bengal is to ensure coolness and prevent rapid fluctuations of temperature in the house. Houses with thick mud walls and thatched roof are suitable. They keep cool in summer and rather warm in winter.

If there be a covered verandah all round it helps moderation of the temperature. The connection of house with success in rearing has been discussed in section 15.

Rearing houses at present adopted by the Bengal department are illustrated in Fig. 55. The plan (Fig. 54) shows measurements of the verandah, the fly killing room and the rearing

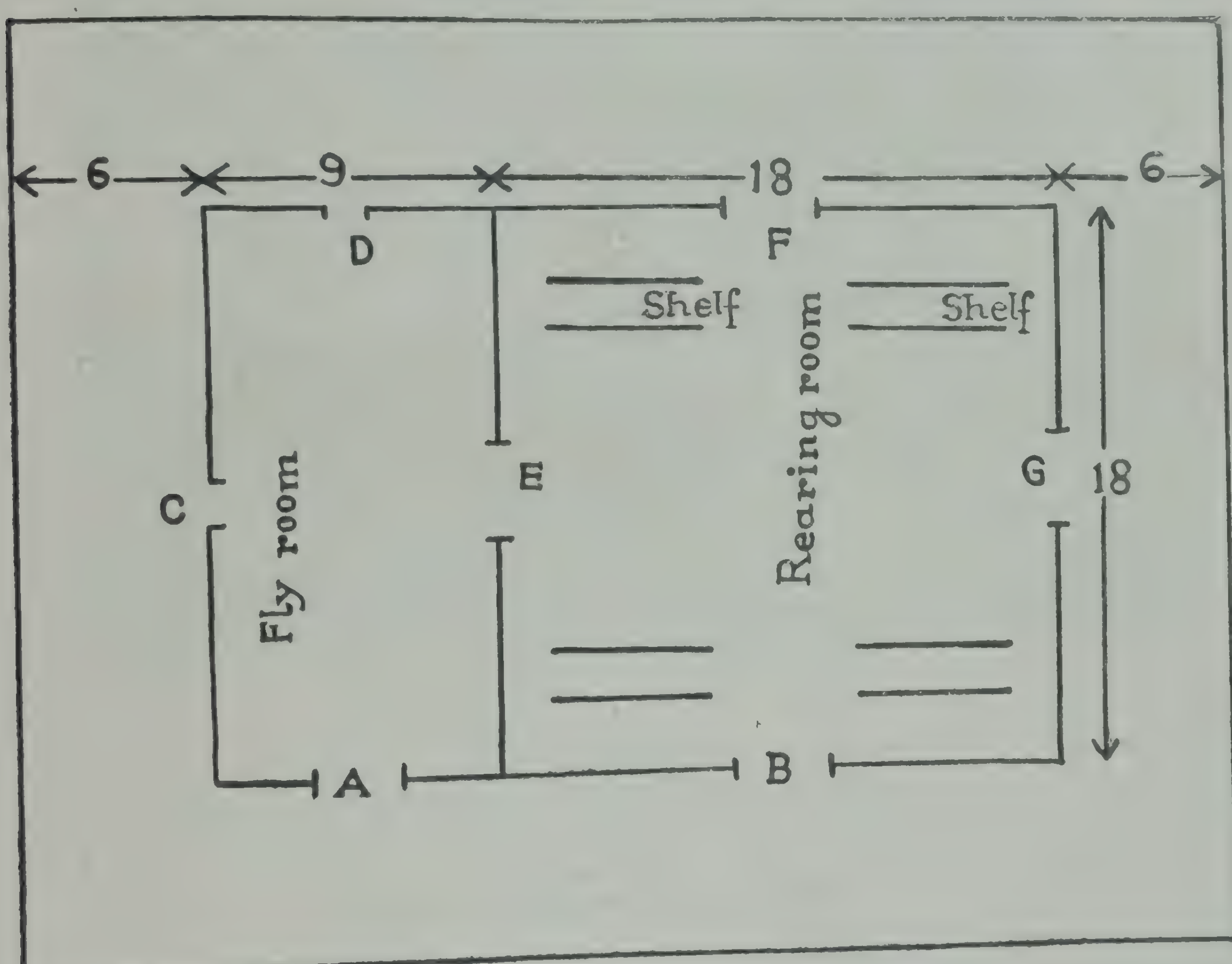


FIG. 54—Plan of rearing house (explained in the text).

room accommodating four *gharas* or 64 trays of worms. The fly room is provided with a low flat ceiling and on entering it the door A is shut and any fly which may have got in killed with a broom before the door E of the rearing room is opened. C, D, B F, G are windows protected by wire gauze thus preventing ingress of the fly or birds etc. The *gharas* or shelves are so arranged that direct wind cannot blow over the worms. In order to ensure further ventilation and escape of hot vitiated air from the room openings are provided on the top of the walls at the gable ends of the houses (Fig. 55) in the form of a small window or still better in the form of about 9 holes made as lattice of bricks and

protected with wire gauze on the outside. The houses are quickly built with unburnt bricks. The exposed part of the walls at the gable ends should be of burnt bricks and plastered with mortar as a protection against rain.

FIG. 55—A thatched rearing house in Bengal.

The Mysore Department has adopted houses of the same nature but without the fly house, with only one verandah in front and with tiled roof. The climate and absence of the parasitic fly allow of such structure.

54. Operations in rearing of worms.

When leaves are available for feeding the worms and rearing accommodation and appliances have been arranged for rearing of worms can be undertaken. As already indicated in section 49 success in rearing requires the use of disease-free seed (eggs). Rearing operations fall into two parts viz. (A) production of disease-free seed to be available to rearers which as already indicated must be under Government control and (B) operations to be carried out by the rearers themselves which consist in :—

1. Securing seed (eggs).
2. Actual rearing of the worms until they form cocoons.
3. Care of cocoons.
4. Disposal of the cocoons.
5. Disinfection of rearing house and appliances.

55. Production and supply of seed.

This involves two operations viz. (1) maintenance of the mother stocks of the desirable races of worms and (2) production of seed to be available to rearers for rearing in different seasons.

The rearers of Kashmir, Jammu and the Punjab are supplied eggs by the respective Departments of those places. The rearers in multivoltine areas procure seed generally as seed cocoons. They make the moths which emerge from the seed cocoons lay eggs in their own houses and rear these eggs. The various Departments are now arranging to supply examined eggs. In Mysore there is a method of taking young worms from professional rearers who make it a speciality of rearing young worms up to about second age and sell them in mass known as *Chaki* or *Chawki*.

56. Maintenance of mother stocks and production of seed.

Univoltine races :—In the case of univoltine races reared in Kashmir, Jammu and the Punjab which import seed from Europe, mainly from France, the mother stocks properly speaking are maintained in Europe. Latterly Kashmir produced locally the major part of the seed used for the season's rearing but mainly from the imported stock. From the best live cocoons known as "seed cocoons" reared from the imported seed moths are allowed to cut. Eggs were taken from them and used in the next season's rearing. As the war has stopped the foreign supply mother stocks are at present maintained locally but they are reported to be deteriorating and their progeny is proving unsatisfactory in rearing. Jammu and Punjab too, began only recently to produce locally a part of their seed requirements from imported stock and they like Kashmir have to maintain and continue the races they have in hand.

Hibernation of univoltine seed :—Univoltine seed requires to be kept under a cold temperature of about 32° F to 40° F or hibernated as it is called, for about four months just before hatching in spring. Without this they do not hatch together and hatching in small numbers in a day may continue for a month or so. Hibernation is therefore an essential operation which is carried out by the sericultural departments of those places, before the eggs are distributed to the rearers.

The Sericultural Department, Kashmir, has a hibernation house at Srinagar. It is a three-storeyed masonry building with double wall on the south side as a protection against sun. The ground storey is the hibernation hall. Tin cylinders are let down into it from the floor of the first storey and the cylinders are filled with ice from the top. Ice is stored in a pit close by the building. There is arrangement for letting out the melted water from the cylinders and for change of air in the hall by means of a fan working at a window. Egg boxes are placed in almirahs in the hall about November and the temperature is gradually brought down to about 35° F, and maintained at about 34° F-35° F for about 3 months till February and then it is gradually raised to 60° F, before the boxes are taken out for distribution.

The Jammu Department has a hibernation house at Batote. It is a one storeyed structure under the shade of trees with conical sloping roof. Inside the building a chamber is built with hollow walls all round which do not rise to the roof and are open at top through which ice is put into the hollow. The chamber is thus open at the top.

For descriptions of use of cold mountain caves and ice for hibernation in Japan see pp. 58 and 109 of *Silk Industry of Japan*. Artificial cold storage plants are now-a-days mostly used in Japan.

Multivoltine worms : Mysore and Madras :—The indigenous multivoltine worm is maintained by the Government Sericultural Farms which supply seed to seed cocoon rearers. In order to ensure health and disease-free condition of the seed cocoon in the hands of the seed cocoon rearers, the Mysore Department very wisely supplies free of charges disease-free, examined eggs to the rearers of Kunigal district who make it a speciality of rearing seed cocoons which are taken for use in rearing in the whole of Mysore and Madras.

The Kunigal rearers do not use any other seed. The stocks are thus maintained in a healthy disease-free condition. This is the arrangement for seed production and supply when rearing is done by general rearers of commercial cocoons with the Mysore race seed cocoons.

Both Mysore and Madras are now producing F_1 cross seed by crossing Mysore race females with foreign univoltine males and supplying this seed as far as possible to the general rearers. For this purpose the Sericultural Departments import foreign univoltine races mostly Japanese, acclimatise and treat them so as to be multivoltine, and maintain them in Government Sericultural Farms. For production of F_1 cross seed sufficient seed cocoons of these foreign races are produced in Government Farms as well as by private selected seed cocoon rearers. The foreign race seed cocoons and pure Mysore race seed cocoons from Kunigal are then collected in Government Grainages as well as in a number of private-aided grainages organised with Government help and crossing of the moths is done as they emerge and the resultant eggs are supplied to the general rearers.

The Mysore and Madras Departments are aiming at replacing the pure race with the cross-breeds.

Bengal :—The rearers of Bengal had so long been used to rearing only from seed cocoons. The Sericultural Department arranged for production of seed cocoons from cellular eggs in Government sericultural farms, called nurseries, as well as by a number of selected seed-cocoon rearers who were supplied with cellular eggs. The rearers take seed cocoons from Government nurseries, selected rearers and also from village rearers who generally rear from unexamined eggs. There is a wrong impression among some rearers that seed cocoons from unexamined eggs and reared without particular care and attention bestowed on them have hardy progeny. Recently the Sericultural Department carried out a propaganda by supplying examined eggs to general rearers and the results have convinced them that examined eggs are better than seed cocoons. Arrangements are now being made for establishing aided grainages for production of examined eggs to be available to general rearers and for supplying free of charge cellular seed to a sufficient number of selected seed cocoon rearers who will supply seed cocoons reared from cellular eggs to the aided grainages and will receive a bonus on all seed cocoons used for seed for the next rearing of general rearers. The Department hopes in this manner to be able to bring into general use the system of rearing only from examined eggs. The Department will maintain the mother stocks as at present.

Selection of seed cocoons :—Live cocoons from which moths are allowed to cut out and lay eggs for use in rearing the next generation are called seed cocoons. Seed cocoons should be taken from the cocoons of worms which hatch uniformly in the largest number on the first day, preferably from worms which hatch on the first day which feed well, moult well, live healthily and spin cocoons healthily.

A lot showing pebrine germs under the microscope in eggs, eggshells, worms, pupae and moths should not be used for seed purposes. In lots intended for seed purposes it is advisable to examine a few eggs, a few empty eggshells after hatching, a few worms in the 3rd, 4th and 5th ages and a few pupae. Such examination enables easy determination whether the lot is fit for use as seed or not. If unfit for use for seed purposes the cocoons can be at once disposed of for reeling. If pebrine germs are observed in these examinations it is sure that moths will show infection. Further work on such lots for eggs means waste of cocoons, efforts and time.

If worms when under rearing suffer from flacherie, grasserie or muscardine diseases care has to be taken to determine whether they can be used as seed cocoons. Worms suffering from muscardine should be rejected wholly. A few worms suffering from flacherie or grasserie do not matter much. But if more than about ten per cent of the worms in a lot die of these diseases that lot is not fit for use for seed purposes.

Even when worms hatch, feed, live and spin cocoons healthily all their cocoons cannot be used as seed cocoons. Worms from well selected eggs usually spin a few cocoons on the first day, the majority on the second day and a few on the third day. Seed cocoons are best kept from the second day's spinning. There should be selection of cocoons themselves.

Cocoons which are well formed, of uniform shape, stiff, with little or no fluff and without any spot should be selected for use for seed purposes. The aim is to have for the same rearing in the same rearer's hand if possible eggs laid on the same day. It facilitates rearing if the eggs hatch together and the worms moult and spin together. The above instructions should be rigidly followed especially in the case of multivoltine worms. The worms tend to split up and extend their periods of moulting and spinning. This can be avoided if selection is carried out in every generation in the above manner.

These instructions apply to the univoltine races as well. But in their case eggs laid on different dates can be mixed as they do not hatch before about ten months and time and uniformity of hatching can be regulated through hibernation and incubation.

57. Operations of the rearer.

Securing seed :—How the seed or seed cocoons are secured has been described above (Section 56). The results are satisfactory if examined eggs are taken and reared. This is the practice in all successful advanced sericultural countries. In Japan production and sale of unexamined eggs is prohibited by law and the Sericultural Department has arranged for production and supply of abundant eggs of desirable varieties. In this way standardisation and uniformity of cocoons have been secured helping production of uniform grades of raw silk.

How eggs are obtained from seed cocoons :—When seed cocoons are obtained for rearing it is necessary to allow moths to cut out from them and lay eggs. It is only necessary to keep the seed cocoons spread on a tray. In time moths will cut out in the morning and mate. The pairing couples should be picked out with hand and placed on a tray. After about four to five hours the couples should be separated and the females placed on a sheet of paper or cloth and each under a separate tin funnel when microscopic examination is intended. In the case of the multivoltine races this examination must be done ordinarily within about seven days after which the eggs hatch. The eggs of moths showing pebrine germs in their body are rejected and those of healthy moths kept for rearing. As there is risk of undetected pebrine germs sticking to the surface of eggshells and as a part of the shell is eaten by the young worm when it hatches out and may thus swallow the germs it is customary as a precaution to wash the eggs in 1 per cent formalin solution with cold water. The eggs stick to the sheet on which they are laid and this sheet or parts of it containing eggs are dipped in this solution for about two minutes and then washed in clear water and dried in the shade. The sheets with the eggs are kept spread on a tray and the worms hatch in time without any treatment. When laid the eggs are yellow in colour which darkens before hatching. In winter some of the eggs of the existing multivoltine races turn steel coloured on about the third day. Such eggs turn univoltine and will not hatch like the other eggs and should be rejected. This indicates that these multivoltines are of hybrid origin. In the case of univoltine worms the eggs do not hatch before about ten months thus allowing of plenty of time for examination after oviposition. The female moths are placed in separate small cloth bags or paper cells usually made in the form of a cylinder with a flat bottom and kept away. They lay eggs and die and dry up if examination is deferred. Parts of their body are taken for examination and selection of healthy eggs carried out as in the case of the multivoltine worms. The eggs are afterwards washed and scraped off, dried in shade and then packed in card board or muslin boxes in half ounce, one ounce or two ounce lots, as desired. From Europe eggs come in one ounce lots. The card board boxes are shallow flat ones with small perforations in the bottom as well as in lid to allow of ventilation. Muslin boxes are made by gumming muslin on both sides of a square or oblong wooden frame made with strips about three-eighth inch thick. On the bottom of card board and on one side of the muslin boxes paper discs are fixed so that when the boxes are stored one on top of the other ventilation may not be interfered with. When eggs are taken from a definitely known healthy lot isolation of the moths in the above manner is frequently dispensed with. A number of moths is allowed to lay eggs on a tray or a sheet of paper or cloth under a cover to keep them from running away. A definite number is usually taken so as to be able to know the number of layings in the lot.

Hatching of eggs :—Multivoltine eggs hatch without any special treatment in ordinary temperature in the plains. Hatching takes place in the morning. When the colour has changed stimulation by gently brushing the eggs with the soft edge of a bird's feather is said to bring about hatching of the largest number on the first day. In a favourable temperature healthy eggs do not require such stimulation and more than 90 per cent hatch on the first day and the remainder on the second day.

In the case of the hibernated eggs of univoltine races which are reared in cold countries, for proper uniform hatching the temperature at which the eggs are kept requires to be raised gradually up to about 75° F. This is called incubation and is brought about with the help of fire in the room. In some countries eggs are carried in a small cloth bag hung from the neck under the clothes thus incubating them with the heat of the body. Incubation chambers are also in use. A simple chamber can be improvised with a wooden box in which a tray of water and a burning lamp are kept. A thermometer is attached to indicate the temperature. For practical purposes a fire is sufficient in the room to raise its temperature so as to make a person feel comfortable in it. This gives a good indication as to temperature for incubation without the help of any thermometer.

The eggs of the univoltine Boropolu race of Bengal are preserved by the rearers in an earthen vessel with its mouth sealed and hung under the roof of a thatched house in a cool corner, thus protecting them against hot winds of the hot weather or rapid fluctuations of temperature. No hibernation or incubation is practised with the result that hatching continues for about three weeks and necessarily many small lots of worms have to be reared. Proper hibernation and incubation help them to hatch within three days. This race had so far been valued for its white cocoons. Availability of much better white cocoons from the introduced Nistid and Nismo races which can be reared any time in the year has practically stopped the rearing of Boropolu.

Care of " Ants " :—The tiny, dark coloured, newly hatched young worms are called " ants ". Ants for the day hatch out before midday by about 11 O'clock when the first feeding has to be given to them. Tender mulberry leaves from the tops of the shoots are chopped into thin strips and these strips are sprinkled over the ants which crawl on to them and begin eating them from the cut edges. After about an hour or two these strips with the ants are removed from the egg sheet and collected together in the form of a flat disc, called *chaki*, and kept on a sheet of paper on a tray. Fig. 56 shows two

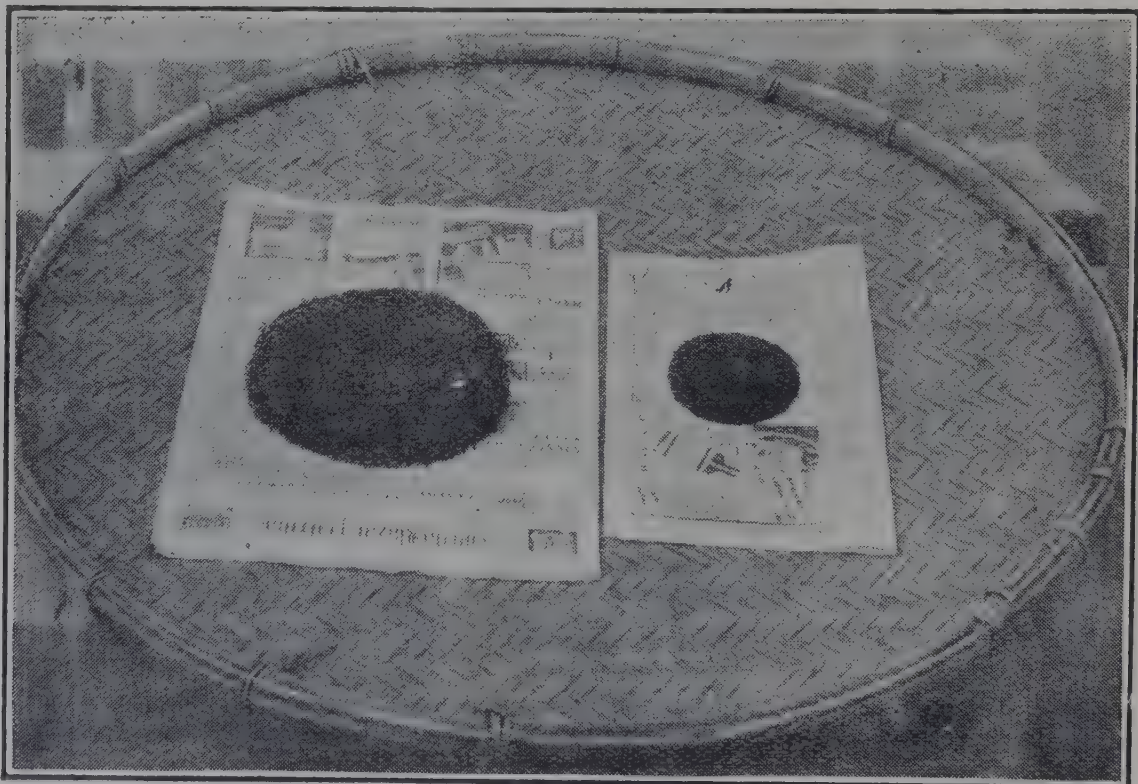


FIG. 56—Two *chakis* or feeding beds of young worms on a tray.

chakis on a tray. This *chaki* forms the bed on the top of which the ants collect and are easily seen. Subsequent feedings are given by sprinkling chopped strips of leaves uniformly all over the *chaki*. Unless care is taken to supply food uniformly all over some ants will starve and cannot keep pace in growth with those which get food and will lag behind in moults. Feeding should also be done at regular intervals during the twenty-four hours of the day and night. In Bengal ordinarily four feedings are given, at 4 p.m., 10 p.m., 4 a.m. and 10 a.m. The number of feedings is increased if prevalence of dry wind causes the leaves to dry up quickly. In Mysore about eight or even ten feedings are given. Older and maturer leaves should be used as the ants grow and the strips, too, should be broader. The ants do not consume all the leaves supplied. The remnants as well as the excreta of the ants collect in the *chaki* which necessarily begins to ferment and rot from the bottom and requires to be changed. Changing of the *chaki* can be very easily done by spreading a piece of ordinary fisherman's net over it and sprinkling food over the net. After about two feedings the net with the leaves and ants can be lifted and placed on another tray. If the ants are overcrowded the *chaki* should be spread out.

After feeding for about four days in ordinary temperature in the plains the worms stop feeding and sit quietly with the forepart of the body raised. The head seems to be getting detached from the body with a distinct elongated neck behind. The worms are preparing to cast off the skin or moult. They should not be disturbed and they do not require any food at this time. After about a full day and night the worm issues as from a bag out of the skin which remains sticking to the spot. The worm now moves about and wants food. Moulting is a sickness and food should not be given until the worm is well out of it. Some worms are a little early and some late in issuing out of moult even in the same lot of worms hatching on the same day. If food is given immediately after the early ones have moulted they will feed and grow more than the late ones. Therefore food should not be given until all have moulted and indicate their hunger by their movements. Rearing work is facilitated if the worms in the same rearing hatch together, moult together and spin together. A good deal in this respect depends on the treatment and feeding given. If worms are irregular in moulting and the early moulters have to wait for a very long period before the late moulters are fit for taking food the former may be driven by hunger to eat dry leaves thus getting diseased. Uniformity in hatching and feeding from the beginning can evade this.

It is the ants or worms in the first age which require the greatest care and skill on the part of the rearer. The future of the lot and success in its rearing depend a good deal on the treatment of the young worms. This is why many rearers' associations in Japan arrange for cooperative rearing at one place of young worms. In Mysore some professional rearers known as *chaki* rearers make a speciality of rearing young worms up to about the second age and the *chakis* are then sold. This is their profession.

Ants which hatch on the second day from the same lot of eggs should be kept and reared on separate trays and should on no account be mixed up with those of the first day. One or two extra supplies in the daily feedings will enable them to come up with the earlier lot by the fourth or fifth age and spin at the same time. The position of the tray in the *ghara* or shelf plays some part in the development of the worms in it. The upper regions of the rearing room being warmer the worms in the topmost trays develop quicker. A skilful rearer counteracts this effect by occasionally transferring trays between upper and lower tiers.

Care of worms in the 2nd age :— The worms require to be fed four times but with maturer leaves and with strips chopped bigger. They should be spread out as overcrowding interferes with growth. The same care as to proper and sufficient supply of food to all the worms in the tray or bed should be observed throughout rearing. The bed is better changed every two days. The worms will go into second moult after feeding for about three or four days after the first moult and require the care in every moult as has been described for worms in the first age.

*Care of worms in the 3rd age :—*Four feedings should be given. Bengal rearers supply small twigs with leaves. If fed with plucked leaves, the leaves if large should be cut into pieces. The trays are better changed every two days.

Care of worms in the 4th age :—The same feeding should be given as in the 3rd age. It may be necessary to change trays every day.

Care of worms in the 5th age :—In this age the worms eat voraciously and grow quickly. Bengal rearers give only three feedings during day and night and whole branches of the bush mulberry pruned at base are supplied with leaves. If fed with plucked leaves they need not be cut into pieces unless very large. The trays require to be changed every day. The worms feed for six, seven or eight days in this age and then become ripe for spinning cocoons. They void a large quantity of excreta and wander to the edge of the tray or bed in search of a corner for spinning cocoons, throwing silken filament from the spinneret. Their body becomes shiny and the colour translucent and golden in the case of worms spinning yellow cocoons. Ripe worms are easily distinguished by the practised eye.

Rearing grown-up worms without trays :—The worms in these ages eat voraciously and require a large number of trays. One tray of worms of 1st age requires about 36 trays in the 5th age. Handling so many trays on and off the *ghara* three times daily when food has to be supplied, and transferring the worms to clean ones every day, besides the cost of trays and nets, make it advisable to try the *jossu-iku* method of Japan. A raised platform is made on the ground or floor of godowns and whole branches bearing leaves are supplied to the worms. As the leaves are eaten fresh branches are placed on top of the bed which is not changed and may be one to two feet high. The worms always rise to the top and feed (Fig. 57). In Kashmir and Jammu rearing is at present done on floors without the

Fig. 57—Rearing of worms without trays. *Jossu-iku* method of rearing. Entire branches bearing leaves are being supplied.

use of trays. It is however advisable to use trays up to the 3rd age or 4th age and raised platforms over the floor make for cleanliness. In Bengal whole branches of bush mulberry are at present supplied to such worms on trays. The high bush and trees will allow of such practice. In Mysore plucked leaves are used and the method will require a change. In Japan it is claimed that this method brings about a saving of about 10 per cent in cost of rearing and about 10 per cent in leaves as they dry more slowly than when plucked. Saving in the cost of trays and nets used in Bengal and Mysore will be considerable. As a large quantity refuse and excreta need not be disturbed and handled every day it will maintain cleanliness and sanitation in rearing house.

Care of ripe worms :—When brush wood is provided at the edge of trays or beds the ripe worms crawl on to them and spin cocoons. In rearing on trays or platforms it is necessary to pick up the ripe worms and place them on the spinning tray. The sooner they are placed in spinning trays the better. Otherwise they waste a lot of silk which would have gone to the formation of the cocoon. The majority of worms void the last excreta in the feeding bed before searching for corners for spinning. A few generally get picked before

this and excrete on the spinning tray. Therefore it is advisable to stand the spinning tray on which ripe worms are being placed with its top tilted forward with the help of a stick (Fig. 49) thus allowing any excreta voided to fall out of the tray. If the spinning worms are kept in warmth they spin cocoons well. Therefore specially in cold weather trays can be stood with their back to the morning and evening sun without letting the sun strike directly on the worms. If it continues to rain when the worms are spinning the cocoons become *gazla* as already described. If however the worm can at this time be kept in a room with fire burning in it so as to reduce the moisture in the air this bad effect of rain can be counteracted. If it be cold fire in the spinning room helps the worms. The worms take about two days to complete the cocoon in ordinary temperature or about three days if it be cold. Then they take some rest inside the cocoon during which the body contracts and pupa formed and then the final skin is cast off liberating the pupa. The body of the pupa is at first soft. Disturbance or rough handling of the cocoon at this time may injure it and body juice of the pupa if injured stains the cocoons, interfering with its reeling quality. If the worms are healthy and have been well looked after those in the same lot should complete spinning in three days. Only a few spin on the first day and this is spoken of in Bengal as *dekha deoa* i.e., the worms have shown that the lot is ripening and the first day's cocoons are spoken as *Chhit pak* cocoons. The majority of the worms ripen on the second day and this is spoken of as *Bharan pak* i.e., full ripening. Only a few remain to spin on the third day and this is spoken of as *Chera pak* i.e., ripening of the remnants of worms. The *Bharan pak* cocoons are the best and in the case of the multivoltine worms especially the *Chhit pak* and *Chera pak* cocoons are much poorer than *Bharan pak* ones.

This order of ripening is disturbed if the worms suffer from disease and starvation and some worms linger on and they produce very poor flimsy cocoons.

Care of cocoons :—The cocoons should not therefore be removed from the spinning tray before the third day in summer and fourth day in winter. Loose fluff or dirts and sticks sticking to the cocoons should be cleaned off. Flimsy or stained cocoons should be separated and disposed of separately. It pays to dispose of good and bad cocoons separately. If bad ones are mixed with good ones the whole lot gets a bad reputation. Moths cut out of cocoons in about nine days in ordinary temperature or in about 14 or 15 days if it be cold. The cocoons should either be disposed of before moths cut out or stifled so as to prevent them being cut and becoming unfit for reeling. Purchasers of live cocoons have to do the stifling. As reeling takes time the cocoons require to be dried and stored. Reeling concerns which purchase cocoons must have arrangements for stifling, drying and storing cocoons.

If cocoons remain long in rearer's hand it is necessary to stifle and dry them.

58. Drying and storing of cocoons.

Raw silk can be reeled from fresh cocoons before drying them but such raw silk cannot be of high quality. Coarse reeling is practised with such cocoons to produce *Ghora* silk in Bengal.

In order to be able to produce raw silk of high quality in filatures it is necessary to dry the cocoons before reeling and in order to be able to store the cocoons for being reeled gradually in the course of the year it is necessary to dry them thoroughly before storage. The cocoons lose about two-thirds of their weight in this process and drying has to be done as quickly as possible. Moths may otherwise cut out and spoil them. The extent of drying necessary to kill the chrysalis is generally called stifling. Even after stifling when the weather is damp unless the cocoons are fully dried quickly mould attacks the dead insects inside and also the cocoon shells which then get spoilt and do not reel. Drying of cocoons is therefore an important and necessary process in an organised industry and proper arrangements for drying is essential.

In Central China cocoon drying stations have been established in country districts as real estate and are available on rent for use. They are controlled by cocoon brokers and filature owners who operate under licence from Government and who rent these stations when they do not possess stations of their own. Cocoon growers are obliged to sell their

cocoons within about a week or sooner in order not to incur loss through moths cutting out. The native silk weavers here were interested in protecting their sources of supply of native reeled silk for domestic weaving and opposed establishment of drying stations which catered for filatures. As a result licensing was introduced. The number of drying stations was limited. Cocoon growers were at a disadvantage as they had to agree to sell off their cocoons at the price dictated by the drying stations. This in a way checked the expansion of the industry. In 1926 the Chekiang Provincial Assembly passed new regulations authorising a steam filature of 100 basins established in the province to have and operate thirty double cocoon-drying stations in any three cocoon-producing areas in the province.

In Japan all filatures and reeling concerns have drying plants in which cocoons are stifled and dried after purchase. When cocoons are purchased at a distance through purchasing establishments such establishments have plants to stifle and dry cocoons partially before they are despatched to the reeling factories where full drying is done before storage. In cocoon-drying and storing stations which Government has been fostering by payment of subsidies amounting to 40 per cent of their cost, there are complete drying plants. Rearers deliver their cocoons here which are stifled, dried and stored and sold to filatures conveniently.

In Kashmir cocoons are reared in May and June when sun is available. Cocoons reared in the neighbourhood are delivered by rearers at Srinagar factory where the department dries them in the drying plant before storage. In distant villages cocoons are dried in the sun before delivery at Srinagar. In Jammu factory there is no drying plant and all cocoons are dried in the sun by rearers before delivery at Jammu.

In Bengal where cocoons are reared throughout the year hot sun is available in the cold and hot weathers and is made use of in drying the cocoons. In the rainy season however in the absence of the sun rearers as well as reeling concerns frequently suffer loss on account of moths cutting out or through mould even when the pupae are stifled but cannot be dried fully. The old reeling concerns maintained stifling and drying chambers, called *atas-ghar* i.e., heating chamber.

In the type of *atas-ghar* in use a large iron pipe in a pit below the level of the floor is heated red hot with wood or coal fuel and cocoons are placed in cane work drawers which are arranged on shelves in tiers above the pipe. The arrangement is not quite efficient. The consequence is that rainy weather reeling season is kept as short as possible. Cocoons reared in this season are not bad and with proper drying arrangement both rearing and reeling are capable of expansion in this season.

In Mysore and Madras, too, rearing cocoons throughout the year there are no drying arrangements. The writer's experiments with the hybrid Nistid and Nismo cocoons showed that cocoons stifled and dried with heat reeled better and produced cleaner raw silk than when dried in sun. The heat dried cocoons could be stored for about ten months with precautions against damp.

A simple drying chamber in which wood or coal can be used as fuel is illustrated in Fig. 58. It is built with bricks and mud and can be made with walls of mud or unburnt bricks. Its inside measurements are 3′×3′ and 5′ high with the oven at the bottom about 1½′ high having iron gratings about 9″ from the floor. Above the oven an iron sheet about ¼ inch thick with about an inch of its edges driven into the walls all round forms the floor of the chamber. About one inch of dry sand covers the sheet which must be of a quality so as not to be warped by heat. Two iron or bamboo rods fixed into the side walls across the entrance form a tier for a tray. The first tier should be about a foot above the sand. The other tiers should be about six inches above one another. A door is fitted to the front wall with a flap or flaps on hinges allowing of trays of cocoons being put into or taken out of the chamber. Trays with about two inch rim and open meshed cane bottom or bamboo trays with open meshes are made to fit the chamber.

In each of the walls at the sides and the back two holes are left about 2″×2″ above the layer of sand to allow of ingress of fresh air. The top of the chamber is flat and made of tiles covered with earth and in its middle a large hole is left. The air in the chamber when heated draws moisture out of the cocoons, rises to the top and escapes through this hole

causing at the same time fresh air to enter into the chamber through the side holes. If the fire burns intensely it is advisable to transfer the lower trays to upper tiers and upper trays to lower tiers at some intervals of time thus avoiding the risk of cocoons getting scorched. If the temperature inside is controlled with the help of a thermometer and kept at between 180° and 200° F there is no risk of scorching. The chamber is better built under a shed and can be used by several rearers to stifle their cocoons or to dry them if necessary.

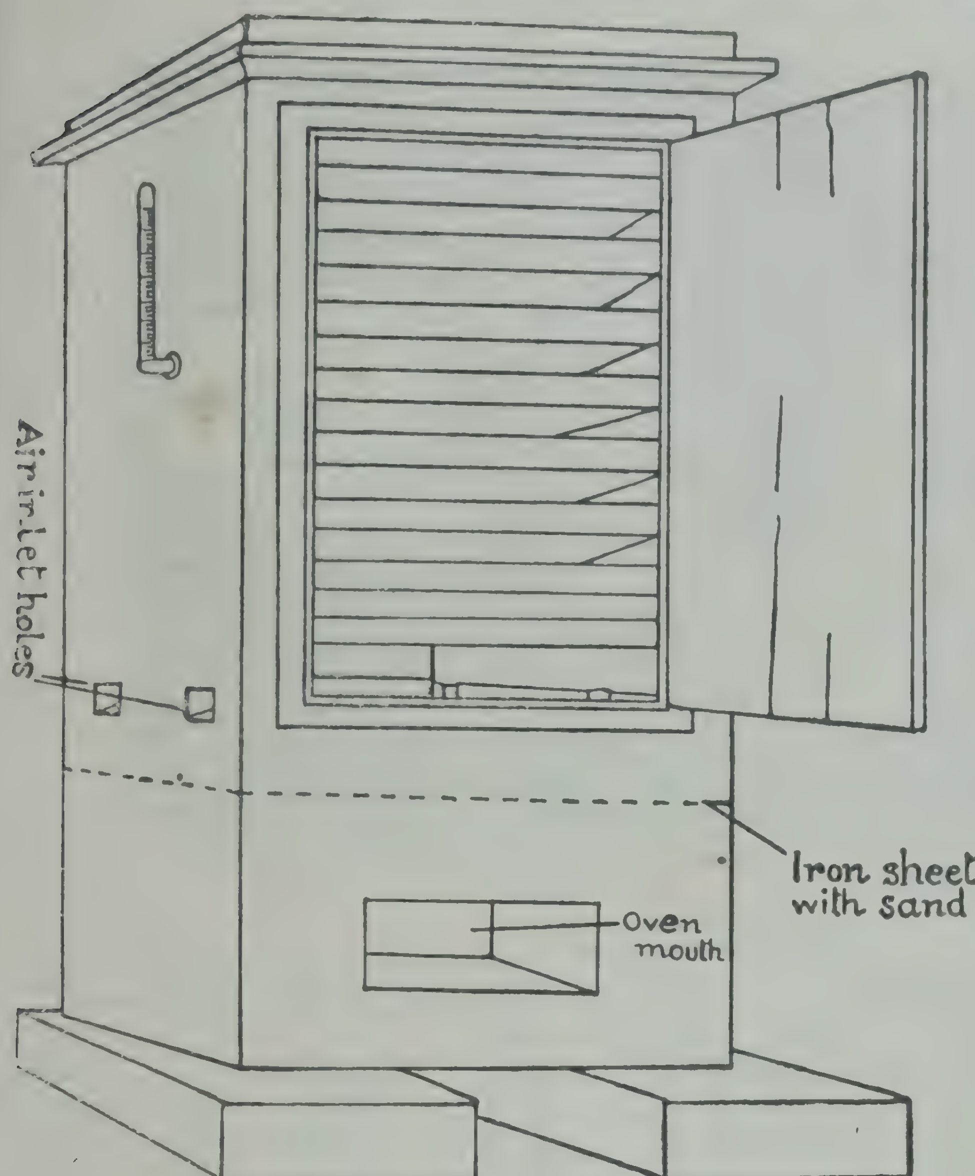


FIG. 58—A simple cocoon stifling and drying chamber. Trays with wooden edges seen inside.

A drying chamber commonly used in Japan and heated with steam from a boiler is shown in Fig. 59. The msaonry walls are double with about five inches of sawdust between. The doors are of double planks with a similar layer of sawdust. The floor is low and fitted with a number of iron pipes connected with the boiler and also with a steam trap. Rails run into the chamber above the pipes for the wooden frame conveying trays of cocoons which can be pushed into or drawn out of the chamber. On one side of the chamber inside there is a fan with large blades which move vertically. The fan is worked by a belting outside the wall and drives the hot air through a chimney above it. A bent thermometer is fitted to the door and the temperature inside can be observed from outside. Cocoons are dried thoroughly in about eight hours with a temperature between 175° and 200° F. On the left side of the illustration dried cocoons are being packed in large moisture-proof paper bags. Such bags of dried cocoons are heaped in the cocoon store.

Large chambers for continuous drying of cocoons with steam illustrated in Fig. 60 rather diagrammatically are in use practically in all large reeling factories in Japan. Cocoons

are fed at one end at the top in a thin layer on a slowly moving, endless wire-cloth which spreads in several folds inside the plant and come out at the bottom ready dried in about six hours.

In Japan modern cocoon stores are large reinforced concrete, fire, insect and rat-proof buildings two to three storeys high with large rooms which are lined with metal sheets. In some cases the inside rooms are of wood similarly lined with metal sheetings. There are arrangements for maintaining the humidity inside at not more than 70%.

FIG. 59—Steam drying chamber (Explanation in the text).

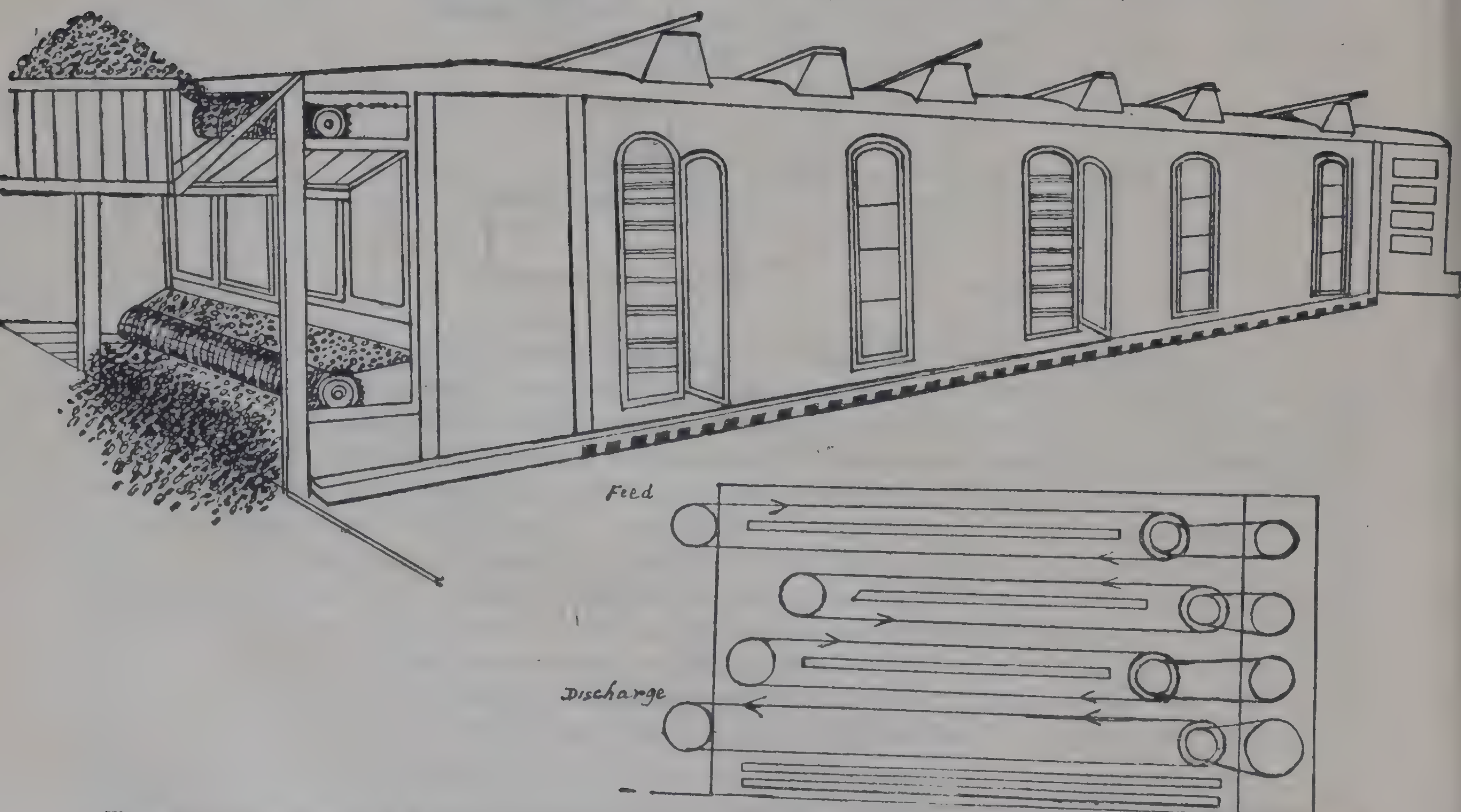


FIG. 60—Continuous drying chamber—Imamura plant for continuous drying of cocoons. Diagrammatic sketch of inside arrangements below.

Cold storage of cocoons :—In Japan a few filatures make use of cold in storing cocoons. The temperature in the store-house is maintained at 0° C to 10° C and the cocoons are stored here without drying. In some places cocoons are dried about half and put in cold storage at about 5° C to 10° C.

The Japanese cocoons are superior univoltine or bi-voltine. Whether multivoltine cocoons can similarly be preserved in cold storage has to be found out by trial.

59. Cocoon crops.

Univoltine worms produce normally one crop of cocoons during the year in spring. Thus in Central China and all the sericultural countries in Europe and the Near East cocoons are available between about the latter part of May and early part of June. The cocoon market therefore lasts for a very short period extending not more than about a fortnight and filatures have to make their purchases during this short time and then dry the cocoons and stock them for reeling during the year. The same is the case in Kashmir and Jammu.

Japan although mostly rearing univoltine worms manages to have three crops of cocoons in spring, summer and autumn, partly through the use of bivoltine races of worms and partly through treatment of univoltine eggs with cold and chemicals in order to make them hatch out of their proper season for a second rearing. The method is not difficult and is capable of adoption by other countries with climate suitable for rearing univoltine races (vide *Silk Industry of Japan*, pp. 58-60).

Countries rearing multivoltine worms such as South China, Indo-China, Siam, Burma, and Mysore and Bengal in the plains of India produce cocoons throughout the year. Small quantities of cocoons can be produced right through the year if leaves are available and in some areas small lots of cocoons are reared in this manner. But for an industry of some volume cocoons must be reared in large quantities requiring consumption of large quantities of leaves. As large quantities of leaves are not available always and they take time to grow cocoons have to be reared in particular seasons. Thus in Bengal the following are the principal crops of cocoons reared in different seasons and the importance of the different crops is indicated by their approximate percentage of the total crop of the year.

Aghrani (November-December)	crop	about	35%
Choitra (March-April)	,,	,,	15%
Jaistha (May-June)	,,	,,	15%
Sravoni (July-August)	,,	,,	10%
Bhaduri (August-September)	,,	,,	25%

The *Aghrani* crop is the largest and the best. Plenty of leaves are available after the rainy season and the climate is favourable. All available leaves are used to rear worms. Then in winter the atmosphere is dry and growth of mulberry is slow and fogs etc., often occurring impede growth. Therefore although the season is good in spring which commences in February rearing cannot be undertaken on a large scale and in fact rearing is delayed. If by improvement in mulberry cultivation a large supply of leaves can be ensured in spring cocoon production can be increased. One method would be to have separate mulberry for spring rearing. In Japan separate mulberry for spring and summer rearing is adopted. In autumn mulberry has time to grow. In between the five principal crops mentioned above in Bengal small crops are reared in different places according to availability of leaves. For instance a *nimkete* crop in certain parts of Malda in October and *Boropolu* worms in January-February in Birbhum and Murshidabad districts.

In Mysore and Madras where although the bush system of mulberry from cuttings is followed the practice is to pluck leaves to be fed to the worms. Also on account of absence of the parasitic fly cocoon crops are overlapping and practically cocoons are reared throughout the year.

60. Gauging of outturn of cocoons in rearing.

The eggs laid by a single mother moth is called a laying of seed. From a lot of seed cocoons approximately about half male and half female moths emerge. Therefore when

a rearer gets a lot of seed cocoons he knows approximately how many layings of seed he expects and he arranges for as many layings as can be reared with the quantity of mulberry leaves at his disposal. The methods of production and supply of seed are different in different countries. In countries rearing univoltine worms in Europe and the Middle East as well as in Kashmir and Jammu the eggs are washed off from the paper or cloth on which the moths deposit them and then dried and packed in loose condition in paper or muslin boxes. France and Italy export large quantities of seed in this manner. The quantity of seed packed in a box is usually one ounce of 30 grammes, although one ounce should contain only 28·3 grammes. The seed locally produced in Kashmir is packed in ½ oz., 1 oz., 1½ oz. and 2 oz. lots for convenience of distribution to the rearers. Also the ounce weight of seed is varied from 30 to 36 grammes according to the race of the worm so that the rearers may get approximately similar quantities of cocoons. In the case of Chinese Golden Yellow 36 grammes seed are put in an ounce in place of 30 grammes for European Yellow. In all such cases the outturn of cocoons is gauged at so many lbs. per ounce of seed. Japan has developed and adopted a system of egg cards in which 28 moths are made to lay eggs separately (Fig. 61). These egg cards with the eggs on them are hibernated and

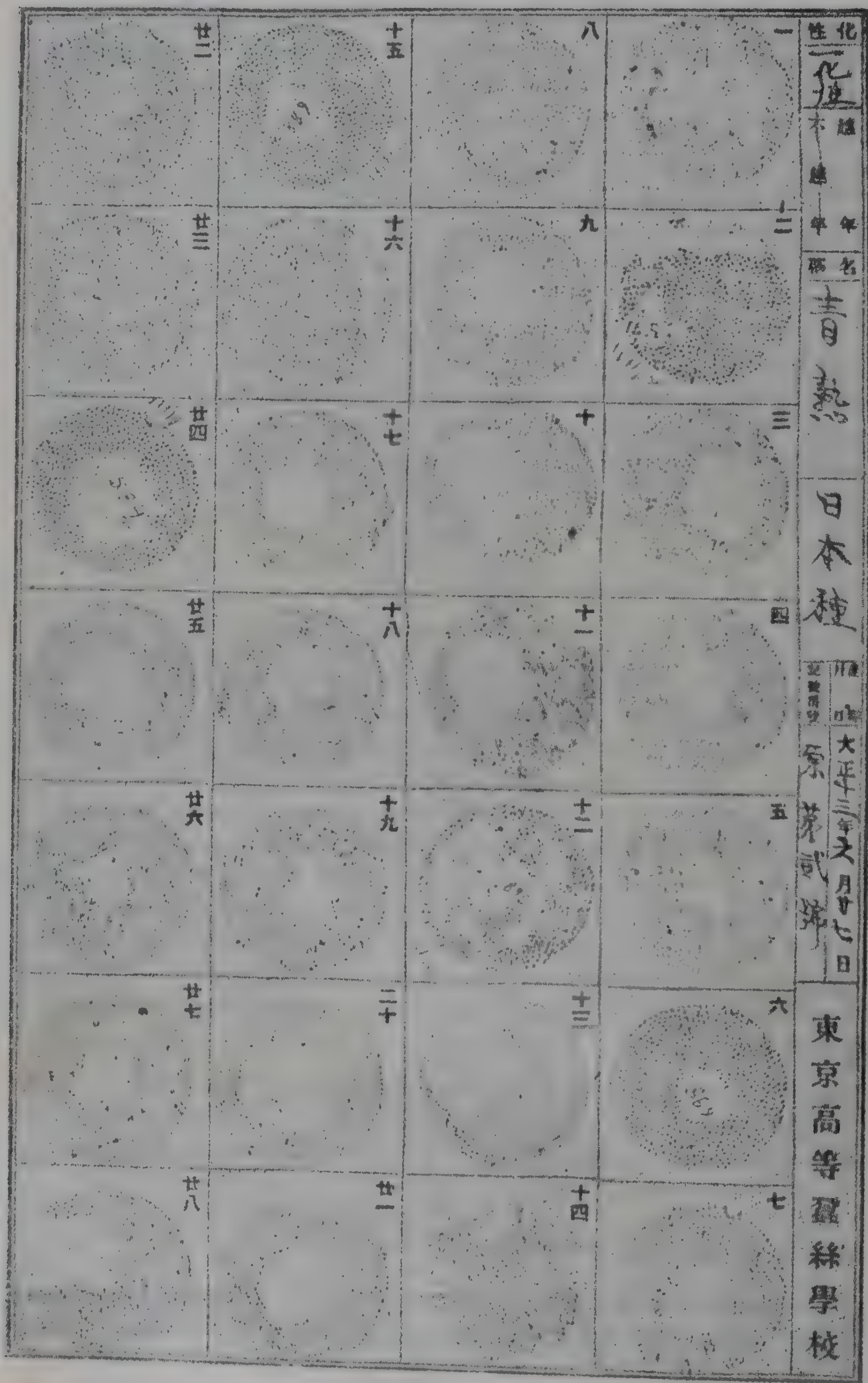


FIG. 61—Japanese egg-card. An egg card with the eggs of 28 moths. Five of the layings contained 688, 571, 584, 368, and 695 eggs.

later sold to rearers. The output of cocoons is naturally gauged at so much weight per card. The twenty-eight layings on the card approximately make about ¼ ounce. The major portion of seed used in Japan is produced and supplied in this form. Another method followed on a smaller scale is to get 45 or even more number of moths to lay eggs promiscuously on a card. In Mysore the local custom is to rear and sell young worms in the form of *chawki* from the eggs of a known number of moths. The Mysore Sericultural Department has now introduced the method of producing and supplying to rearers examined layings, described as D.F.L. i.e. disease-free layings and gauges the outturn of cocoons at so many pounds per 100 layings.

In Bengal the rearers had so long been following the custom of procuring seed in the form of seed cocoons by weight (1 tola = wt. of a silver rupee = 180 grains troy; 5 tolas = 1 chatak 16 chataks = 1 seer—approximately 2 lbs.) or count in *kahon*, *pon* and *gonda* (4 cocoons = 1 *gonda*; 20 *gondas* = 1 *pon* i.e. 80 cocoons; 16 *pons* = 1 *kahon* i.e. 1,280 cocoons). In the case of the indigenous Nistari, Chotopolu and Boropolu races one kahon of seed cocoons generally weighs about one seer. The rearers generally gauge their outturn of cocoons as so many seers per kahon or seer of seed cocoons used. The Sericultural Department is now introducing use of examined seed and naturally counts in layings have to be adopted. In the case of the multivoltine races of worms the eggs hatch ordinarily in the course of about a week on the tray or paper on which laid and do not require to be scraped off and packed in lots of definite weights as in the case of univoltine races. Outside enquirers like the Tariff Board want information regarding outturn of cocoons per ounce of seed in the case of the multivoltine worms also. This does not seem to have been ascertained as no necessity had been felt for it and an imaginary figure of 140 layings per ounce was supplied to the first Board and followed also in the case of the second Board. This information has been found to be wrong. Besides, even in the case of the same race of worms the number of eggs laid by the moths and necessarily the number of layings going to an ounce vary in different seasons.

Krishnamurthi in Mysore has found the following variations (Report of 2nd All-India Sericulture Conference, pp. 48-49) :—

	Average No. of eggs per laying.	Average No. of layings going to an ounce (28·3 grammes).	Approximate No. of eggs per ounce (28·3 grammes).
Mysore race	289 to 368	141 to 174	45,000 to 57,000
Cross-breed races	307 to 389	147 to 171	47,000 to 64,000

In Bengal from the records of the Government seed-producing nurseries the following facts are gathered in the case of the races of worms at present reared on a large scale.

	Average No . of eggs per laying.	Average No. of layings going to an ounce (28·3 grammes.)	Approximate No. of eggs per ounce (28·3 grm.)
Nistari	235 to 360	183 to 365	61,000 to 94,000
Nistid, Nismo	315 to 410	145 to 160	45,000 to 61,000

With wider variations in climatic conditions in Bengal than in Mysore when the moths are overtaken by cold or heat they lay a smaller number of eggs than under normal conditions. The number of layings going to an ounce is then naturally very high.

The following numbers of eggs going to an ounce in the case of different univoltine races reared in Italy published by Mudaliar (Rept. 2nd All-India Seri. Conf., p. 43 *et seq*)

may be compared with the above. In these cases one ounce is taken as equivalent to 25 grammes.

China races about	..	..	40,000 to 54,000
French races about	..	..	33,000 to 39,000
Japanese races about	..	..	46,000 to 53,000
Italian races about	..	..	33,000 to 36,000
Persian races about	..	..	28,000 to 46,000
Turkish races about	..	..	34,000 to 38,000
Spanish races about	..	..	33,000
Italian × Chinese Cross		..	34,000 to 51,000
Italian × Japanese Cross	..	..	48,000 to 49,000
Italian × Italian Cross	..	..	36,000

In Kashmir in the case of the univoltine seed reared locally 90 to 160 layings go to an ounce, in different races, the average being 100 to 110 layings. As regards actual yield of cocoons, in France yields of about 100 lbs. (from an ounce of seed) are not uncommon and in Italy 120 lbs. is not considered exceptional (Rept. of Ind. Tar. Bd., 1934, p. 74). In Japan in 1936 the yield was 157 lbs. in spring crop and 111 lbs. in summer and autumn crops (Ind. Tariff Board, Written Evidence, 1940, p. 1144, calculated). In Kashmir the average yield from an ounce of seed for five years ending 1936-37 was about 66 lbs. and in Jammu about 87 lbs. (ibid, p. 217, calculated). In the Punjab the average yield from locally produced seed was about 66 lbs. (Rept. 2nd All-India Seri. Conference, p.97). All these yields are of univoltine races of worms. For the reasons stated above an exact comparison of these yields with those of the multivoltine races reared in Bengal, Mysore and Madras is not possible, as the number of eggs laid by the moths and the size and weight of the eggs themselves vary in different seasons and the seed is never kept by weight. In fact it is practically difficult to do so. The rearers in Bengal who use seed cocoons for seed purposes calculate that 100 seers of green cocoons on the 3rd day of spinning from a seer or kahon of seed cocoons is a satisfactory outturn and quantities down to 80 seers are fair. Unless the rearers get 5 seers cocoons from 1 chhatak seed cocoons i.e. 80 seers from a seer of seed cocoons the outturn is considered below normal. Such results are common unless food or climatic conditions cause a decrease. In the case of Nistari a kahon i.e. 1,280 of seed cocoons weighs about a seer. About 500 female moths are obtained on the average from them and their eggs may be about two or two-and-a-half ounces in weight. Therefore a yield of about 80 to 100 lbs. of cocoons is generally obtained from an ounce of seed. When layings are used about 2·5 to 3 layings yield a lb. of cocoons. In the case of Nistid and Nismo races $1\frac{1}{2}$ layings yielding a lb. of cocoons is now common and even 1 laying yielding a lb. of cocoons in common in the winter and spring seasons. This makes about 140 lbs. of cocoons per ounce of seed.

In Mysore the yield of cross-breed cocoons is now reported to be about 52 to 59 lbs. per 100 layings (Ind. Tariff Board, Written Evidence, 1940, p. 21) or less than two layings per lb. of cocoons or about 80 lbs. or more per ounce of seed. It will thus be evident that in yield of cocoons by weight the multivoltine races especially the new hybrids Nistid and Nismo of Bengal compare fairly well with the univoltine races of even Japan and Italy. The difference is in the quality of cocoons as regards silk content and filament length and this difference can be lessened in the case of specially the Bengal hybrids Nistid and Nismo and the F_1 cross seeds of Mysore and Madras by taking care so that the quality of food may be improved thus providing the worms sufficient and good food in all seasons and as far as possible rearing houses and methods may be adopted which will counteract the evil effects of adverse climatic conditions when they prevail during the rearing season.

The easiest way of gauging the yield of cocoons in the case of the multivoltine worms when layings and seed cocoons are used would be to take the number of layings which yield a lb. of cocoons. This might be adopted in all places.

61. Disposal of cocoons.

Close relationship of cocoon rearers and reeling concerns :—Silkworm rearing is undertaken for the sake of cocoons and rearers get money by selling cocoons to reeling concerns. The sooner the cocoons are sold the better for the rearer in whose house they may be injured by ants, rats etc. and if sale is delayed moths may cut out rendering them useless for reeling purposes. It is the interest of reeling concerns to secure cocoons, stifle and dry them and then store them properly and gradually reel them. Filatures which have proper arrangements for stifling, drying and storing cocoons are able to produce good raw silk. Badly treated cocoons may not yield suitable raw silk of good quality. The relationship of cocoon rearers and reeling concerns is very close and both profit if they can work in close cooperation without the intervention of any middleman or broker. The rearer should have direct dealing with a reeling concern to which he can deliver the cocoons as soon as formed, take part payment if necessary and final fixation of price and settlement of accounts should be made on the sale of the resultant raw silk.

The price of cocoons is dependent on the price fetched by the raw silk produced from them. It is easy to determine the cost of transit of cocoons to the filature and their treatment and reeling with a margin of profit to the reeling concern. The balance left out of the price fetched by the raw silk gives the price the cocoon producer gets. If rearing and reeling be carried on in this manner in close cooperation between the cocoon grower and the reeling concern neither of the party loses. The rearer has an assured market for his cocoons, gets higher price when the market for raw silk is higher or when his cocoons are of a better or superior quality and yield more or better quality raw silk. If the reeling concern can gain the confidence of the cocoon growers and convince them that it is dealing fairly with them it will never be in want of cocoons and will never run the risk of loss. It is therefore in the interest of both the parties to get into touch and cooperation with each other. This is the best method of disposal of cocoons on the part of the rearers and also of securing cocoons and good cocoons on the part of the filature.

The cocoon grower and the filature are dependent on each other. The former has no market for his cocoons unless there be reeling concerns to purchase them. As has been explained in section 11 the closing down of the European and then of the Indian reeling concerns was the direct cause of the contraction of sericulture in Bengal. It has also been described how during the period of the last depression the Japanese Government and also the Government of His Highness the Maharaja of Kashmir and Jammu kept their reeling industry alive even at enormous loss. When prosperous days returned the industry recouped the losses. But in the case of Bengal and partly in that of Mysore also the Departments are struggling to re-establish the reeling industry and are not in a position to take advantage of the return of prosperity. The rearers require to be educated to their responsibility and duty in their own interest to help in the maintenance of the reeling industry and State authorities should be fully alive to take whatever steps are necessary not to let the reeling industry die. If the cocoon growers, reeling concerns and the State realise their respective responsibility and act accordingly the problem is easily solved.

Methods of disposal of cocoons in Japan :—It is helpful to know how cocoons are disposed of in Japan which has most successfully organised this industry. The best method is one in which large reeling concerns arrange for supply of proper type of eggs to their clientele of rearers and take all the cocoons produced by the latter on condition of payment of price according to quality and yield of the cocoons. Well-organised reeling concerns maintain their own egg-producing establishment and grainages to produce superior seed for their clientele of rearers and take care that their seed which they claim to be superior does not find its way to others.

The next best method is one in which the rearers attach themselves to a cocoon-storing agency or association which has arrangements for receiving stifling, drying and storing cocoons and selling them on mass scale to reeling concerns. The association sets up proper drying chambers and efficient cocoon stores which are ant, rat, damp and fire proof and keep the cocoons in good condition as long as desired. The Japanese Government encourages such establishments and pays a subsidy of 40 per cent towards the cost. The

rearers bring their entire produce to the association where the cocoons are sorted and bad flimsy unreelable ones are returned to the owners who dispose of them elsewhere. The rest is weighed and about $3\frac{1}{3}$ lbs. of the cocoons is sent to a Government reeling factory attached to an experimental station for being reeled in order to determine the rate of yield. The cocoons of all rearers are mixed up and payment for them is made on the basis of the price of the resultant raw silk and the rate of yield already determined. The association charges a small commission.

The third method of disposal is for rearers' associations which are village organisations to dispose of their cocoons together and therefore in bulk to a reeling concern or to a cocoon storage agency or association.

The fourth method of disposal is through what may be described as cocoon marts established and run by private concerns. These concerns set up buildings to receive and store cocoons temporarily and generally have drying chambers to carry out stifling. The cocoon growers bring their cocoons which are poured out on a platform for the inspection of prospective buyers who are usually agents of reeling concerns. After inspection each of the buyers notes his offer with chalk on the inside of a saucer which is passed on to the presiding officer of the mart with its face down so as to keep his offer secret. The officer examines the offers and lets the highest bidder have the cocoons. The cocoons are then weighed and payment made immediately usually in the form of a cheque which the rearer can cash in the village bank. A commission is charged by the mart both from the buyer and the seller. The cocoons are then stifled and in some cases dried up to 50 per cent by the mart if desired for a charge and then despatched to the filature concerned which dries fully and stores them.

The above are the organised methods of disposal of cocoons. Other methods are also followed. In one rearers take their cocoons to the house of a purchaser who acts as a broker to a reeling concern or sells the cocoons he purchases as best as he can. In another a man goes about rearers' houses making purchases.

The above organisations and methods of disposal of cocoons work smoothly in Japan because of the uniformity of cocoons brought about through research and through rearing of the same races of worms by practically all rearers. If a large variety of cocoons were reared they could not admit of being mixed up and price calculated on the mixed lot for different rearers.

Methods followed in Kashmir and Jammu :—In Kashmir and Jammu the rearers are bound to deliver all their cocoons to the filatures at Srinagar and Jammu, where weighment is made at the time of delivery and payments also made. These payments really represent remuneration for the labour of rearing the worms, as the State supplies seed and leaves free of charge.

Methods followed in Mysore and Madras :—In Mysore and Madras the rearers dispose of their cocoons as best as they can to reelers. The Mysore Silk Filatures Ltd. have made grainage arrangements for producing seed for supply to rearers from whom the resultant cocoons are purchased. The Mysore Sericulture Department at first set up three cocoon markets where the current price of raw silk was displayed, the rearers brought their cocoons and buyers bought them after settling the price between themselves. The officer in-charge of the market saw to the correct weighment. Only an infinitesimal part of the cocoons which changed hands passed through these markets. On account of control of silk prices for war purposes the Madras and Mysore Governments have established cocoon markets through which all cocoons are required to be sold.

Methods followed in Bengal :—In the past prosperous days in Bengal a system was in vogue of reeling concerns purchasing cocoons from the rearers through *Paikars* or *Dalals* i.e. brokers who charged a small commission on the money value of the purchase at about 1 to 2 per cent. This system still continues in cases of large purchases when made by reeling concerns. As regards weight the custom of *chhit* is followed (see section 66). The rearers weigh their cocoons soon after removing them from the spinning trays, that is, usually on the evening of the second day of spinning and the purchasers have to accept this weight. Frequently false statements are made about this weight and purchasers of

cocoons are cheated. A system requires to be adopted which will enable determination of approximate yield expected out of a lot of cocoons on any date and in any state of dryness. This is possible and how this can be practically done is shown in section 66-viii.

In Bengal control of silk prices imposed in 1943 for securing silk for war purposes at a reasonable price but without the establishment of cocoon markets failed to secure cocoons, which were sold by all sorts of tricks in the black market where prices more than double the control rates were obtained for them.

62. Purchase of cocoons.

Rearers, the majority of whom are poor cultivators, are in need of ready cash for the cocoons they produce and sell. Even if the best method of disposal of cocoons described above, i.e. through cooperation between filatures and cocoon rearers come into vogue, it will be necessary to arrive at an approximate price in order to enable the reeling concern to make part payment. The question is how to arrive at this price. The price of cocoons is calculated on the basis of the following, viz.

A. The price which the resultant raw silk is expected to fetch.

B. Expected yield of raw silk from the cocoons.

C. Cost of reeling out the raw silk from the cocoons and marketing it.

This includes transit charges, expenses for stifling and drying the cocoons, their storage and distribution to reelers in the factory, reelers' wages, fuel, water, examination, packing and marketing. The overhead charges and profit of the reeling concern are also included in it.

A and C are known factors and the price which can be paid for cocoons can be worked out.

The price of raw silk fluctuates very much and is regulated by conditions in the world's market. In the unorganised state of the industry in India it becomes difficult to know the price prevailing in different markets and the trend of prices whether they are likely to rise or fall, unless there be special circumstances, for instance, the present war which has prevented imports and stimulated the demand in the country. In Japan the price of raw silk ruling in the Yokohama Rawsilk Exchange regulates the price of cocoons. Thus for instance the price of a bale ($133\frac{1}{3}$ lbs.) of raw silk is 1,350 yen. The item C is known and say it is 350 yen per bale. Therefore 1,000 yen is the price of the cocoons required to produce this bale. The unit measure of raw silk taken for transactions in cocoons is one Kan (=8·27 lbs. which is $\frac{1}{16}$th of a bale of raw silk). Cocoons required to produce one Kan raw silk form the unit for transactions in cocoons. Therefore the price of this unit is 62·5 yen and 62·5 is called *Kakeme* or simply *Kake*. The transactions in cocoons throughout Japan are carried on according to *Kake*. As practically the same kinds of cocoons are produced all over the country there is no difficulty. All reeling concerns as well as cocoon growers keep themselves informed of the prices ruling in the Yokohama Exchange. Cocoons pass hands when they are somewhat advanced in age and at least about a week old and have thus dried to some extent. If on examination they are observed not to have arrived at this stage transaction is delayed for one or two days. *Kake* connotes that the yield of raw silk from the cocoons being dealt in is to be taken as ten per cent of their weight i.e., rendita is ten. If the rendita is higher or lower the price of the cocoons will be lower or higher according to the following formula :—

$$\frac{Kake \times rendita}{10} = \text{actual price of the unit i.e. 82·7 lbs. cocoons under transaction.}$$

In the absence of some such organisation, in the case of several small reeling concerns in Bengal whose accounts were scrutinised it was observed that in some seasons they actually incurred a loss in their reeling operations though gained in other seasons. They used their common sense and experience while purchasing cocoons through haggling with the rearers as to the probable yield from the cocoons purchased, although they had a fair idea of the price the raw silk would fetch. That is probably the case with the majority of the numerous small reeling concerns at present carrying on reeling as they have no scientific

system to guide them. At present the cocoons of each rearer have to be haggled over. A simple system of testing their approximate yield will help the purchaser and if such a system comes into universal use both purchasers and sellers of cocoons can confidently carry out transactions without fear about gain and loss and anxiety as to whether one is being cheated by the other.

A reliable test is to mix up the lot of cocoons well and find out the yield by actually reeling 1¼ seers (2½ lbs.) of cocoons and multiplying the resultant raw silk by 32 to know the yield per maund of cocoons (maund=40 seers of 80 tolas each=82 lbs.). Maund is the weight followed in Bengal.

In testing the reelability of cocoons and probable yield actual reeling is advisable especially in the case of multivoltine worms. Cocoons apparently good, like *gazla* ones, may not reel at all and good quality raw silk may not be available from them.

It is advisable for reeling concerns to form a sort of association among themselves, keep themselves informed of the trend of prices of raw silk and fix prices which can be offered for cocoons so that neither they themselves nor cocoon growers lose in the transaction. It is essential for them to create an atmosphere of confidence among illiterate cocoon rearers who only can produce and supply them the raw materials for their work. When cocoon growers get better prices if they produce better cocoons it is an incentive for bestowing greater care and attention to improve the quality of cocoons. Section 66 should be referred to for a detailed discussion about the quality of cocoons and a fairly approximate price can be arrived at for any lot of cocoons without actual reeling as described under sub-section viii.

63. How rearing of worms for cocoons can be carried out successfully.

The essentials for success in rearing have been described above. But for convenience they are briefly noted together.

1. Arrange for the best food for the worms. In order to have the tender leaves for young worms a little bush is useful. But growing worms are best fed with plucked leaves from high bush and trees. At least in the last age worms should be fed with such leaves.

2. Get examined eggs from grainages working under Government supervision.

3. Worms hatching on different days should not be mixed up but reared on separate trays.

4. Supply leaves to the worms in such a way that all worms get food equally.

5. Young worms should be fed with tender leaves and as they grow gradually maturer leaves should be supplied. Do not supply tender leaves after feeding the worms with mature ones.

If the worms are fed with bush leaves right through, break off the tender tops of all the plants in the field from which the growing worms will be fed when the worms come into second or third age. This stops further growth of the plants but causes the leaves already present to grow and mature by the time the worms enter the fifth age.

6. Never feed the worms with leaves which are wet or dry or covered with dust or affected by mould or rust. Dust from the rearing floor settling on leaves fed to the worms is a source of disease. If the floor be of mud applying liquefied cowdung on it prevents dust.

7. Do not disturb or feed moulting worms. After a moult wait until all the worms are well out of the sickness and indicate their hunger by movements.

8. So arrange the rearing that all worms in a tray go into moult at about the same time.

9. Feed the worms at regular intervals during day and night. With proper and sufficient supply of leaves at each feed four feedings are enough during day and night for worms in the first four ages and three feedings in the fifth age unless the atmosphere be so dry as to cause the leaves supplied to dry up quickly. Both overfeeding and underfeeding

should be avoided. Practical experience in rearing gives an indication as to how much leaves should be supplied so that there may not be unnecessary wastage and at the same time the worms may not starve. The worms should indicate their hunger by movements at the feeding time and there should not be much green leaves left over from the last feeding.

10. Spread the worms as they grow. Overcrowded worms do not grow properly and form smaller cocoons than when given opportunity to grow normally.

11. Keep the trays of worms in such a way in the rearing house that no wind blows directly over them. At the same time the house should be well ventilated.

12. In order to prevent the parasitic fly if present from being able to get at the worms protect the doors and windows with wire-gauze or bamboo blinds (*chiks*).

13. It is advisable not to allow others doing rearing at the same time to enter your rearing house as a precaution against diseases through contamination. For the same reason it is inadvisable to use trays, nets, spinning trays or bontis belonging to others without disinfection.

14. Worms suffer from disease if kept under insanitary conditions. Therefore it is necessary to change beds and trays when refuse leaves and excreta accumulate on them and ferment.

15. Millions of worms are reared at the same time. Even if there be no epidemic a few worms are likely to get diseased. Diseases spread mainly through excreta. Therefore the refuse from the beds and trays must be removed with care without disturbing and stirring them too much. As disease germs are borne by air it is advisable to cover such refuse with cowdung in the cowdung heap or with earth in a pit. Fresh refuse from the rearing house should not be applied or thrown in the mulberry field, especially of bush mulberry.

16. As soon as the worms ripen for spinning they should be transferred to the spinning tray.

17. Do not remove and gather cocoons from the spinning tray before the third day in summer and fourth day in winter. Keep flimsy, spotted or crushed cocoons separately.

18. Keep in touch with a reeling concern and make over the cocoons to it soon after gathering them from the spinning tray.

19. Clean, wash and dry the rearing appliances for several days in the hot sun or disinfect them and store them for the next rearing. Clean the rearing house.

20. Supply of good nutritious leaves and care about cleanliness are the best preventives of disease.

64. Disinfection after rearing.

Millions of worms have to be reared together and in the same house. Even when the lot is healthy it is not unlikely that a few may be diseased. Therefore even when there is no epidemic it is advisable and necessary to take precautions against disease occurring in the succeeding rearing. The rearing room or place should be thoroughly cleaned. The trays, nets and all appliances should be thoroughly washed and cleaned and dried in the hot sun for several days and then stored for future use. If there be no sun and especially if there had been an epidemic disease among the worms it is necessary to disinfect the rearing house as well as the appliances in addition to cleaning and washing.

Disinfection can be done in various ways :—

The best form of disinfection is with formalin. With formalin as available in bottles (40%) one part is mixed with 40 parts water to make up the solution for use. After the appliances and room are cleaned and dried, they are wetted with this solution and left in the room shut up for about a day.

Disinfecting solution can be prepared with bleaching powder (chloride of lime) with chlorine content of not less than 25 per cent. Bleaching powder requires to be stored in airtight receptacles. Otherwise it loses its properties. The solution is to be prepared

immediately before use. Ordinarily 1 part is enough in 1,000 parts of water. Strong solution 5 per cent can be used. In that case the appliances etc. should be kept wet with it for about half an hour and then washed with water.

Disinfection can also be done with hot steam. An airtight receptacle is necessary in which the appliances are placed and which is then filled with steam until the temperature goes up to 212° F and left there for about half an hour.

In the case of bad epidemic sulphur should be used in addition to disinfection. The appliances are placed inside the rearing room in which sulphur is burnt and the room shut up for about 24 hours. Powdered sulphur is placed in an open metal or earthen pot which is placed on a charcoal fire. The sulphur burns slowly and emits fumes filling the entire room.

PART V.

REELING.

65. Reeling out raw silk from cocoons.

✓

A GENERAL description of how raw silk is reeled out of cocoons has been given in section 5. Manufacture of good raw silk is dependent on the following factors viz. :—

1. Quality of cocoons.
2. Efficiency of reeling machinery and methods followed.
3. Skill of the reelers.
4. Treatment of the cocoons before reeling.

66. Quality of cocoons.

In order to judge the quality of cocoons several things are considered viz. :—

(i) Weight, usually taken in green state and indicated by *chhít*, a convenient word used in Bengal.

(ii) Silk content i.e. weight of the silky shell indicated as percentage of the weight of the shell to that of the green weight of the cocoon together with the pupa.

(iii) Filament length i.e. the length in yards of the continuous filament reelable from the cocoon.

(iv) Denier i.e. thickness of the filament.

(v) Reelability index i.e. percentage of the weight of the reelable filament to the weight of the silky shell.

(vi) Rendita indicated by the number of pounds or seers of green cocoons required to produce one lb. or one seer respectively of raw silk.

(vii) Reelability defects of cocoons.

(viii) How to judge the quality of cocoons as regards yield and evaluate and pay for them.

I. *As judged by weight—chhit* :—In Bengal counting of cocoons is done in *kahon*, *pon* and *gonda*.

4 cocoons = 1 *gonda*.

20 *gondas* = 1 *pon* (i.e. 80 cocoons).
16 *pons* = 1 *kahon* (i.e. 1,280 cocoons).

Among the rearers the quality of cocoons is indicated by a word *chhit* which is used to indicate the number of *pon* of cocoons going to a seer by weight.

The Bengal or railway seer is 80 tolas in weight (1 tola = 180 grains = the weight of a silver rupee coin) or 14,400 grains and is slightly more than two pounds avoirdupois (1 lb = 7,000 grains; 1 seer = 2·05 lbs.; 1 maund = 40 seers).

The cocoons are weighed on being removed from the spinning tray usually on the second day evening after commencement of spinning. This should be done on the third day morning in the hot and fourth day morning in the cold weather in Bengal. Such cocoons are known as green cocoons and the *chhit* is on green weight.

The other way of indicating the same thing is the number of green cocoons going to a pound. The less the number of cocoons going in a pound or seer the better the quality. In ordinary transactions for cocoons *chhit* is the only criterion considered for quality.

The *chhit* of cocoons reared under Bengal conditions varies with climatic conditions and quality of food given to the worms. In this connection section 15 should be consulted.

The *chhit* observed for cocoons of different races of worms is as follows :—

		Chhit. Highest.	*Chhit.* Lowest.	Number per lb. Highest.	Number per lb. Lowest.
Nistid, Nismo	New fixed hybrids.	8 *pons*	12 *pons*	320	480
Nistari, Chotopolu, Boropolu	Old indigenous	14 *pons*	20 *pons*	560	800

The following *chhit* of cocoons reared in Mysore (Written Evidence, Indian Tariff Board, p. 103) is recorded. Whether it is the highest or average is not stated.

	Chhit (Average).	Number per lb.
Pure Mysore	14 *pons*	550
Mysore × Chinese Univoltine F_1 ..	12 ,,	486
Mysore × Chinese Bivoltine F_1 ..	12 ,,	488
Mysore × Japan Univoltine F_1 ..	12 ,,	483
Mysore × Japan Bivoltine F_1 ..	12 ,,	481
Mysore × French Univoltine F_1 ..	9½ ,,	384

The following *chhit* is recorded of univoltine cocoons reared in Jammu (ibid., p. 214).

	Chhit. Highest.	*Chhit.* Lowest.	Number of cocoons per lb. Highest.	Number of cocoons per lb. Lowest.
Cross Chinese ..	6¼ *pons*	6¾ *pons*	250	272
Bagdad white	4 ,,	5 ,,	159	204
European yellow ..	4½ ,,	5½ ,,	182	222
Chinese golden	6¼ ,,	8 ,,	250	318
Chinese white	8 ,,	9½ ,,	318	386

The following *chhit* evidently average is recorded of univoltine cocoons reared in Kashmir (ibid., p. 239).

	Chhit (Average).	Number per lb. (Average).
Cevennes (French) ..	6 *pons.*	244
Pyrennes (French) ..	6 ,,	236
Var (French)	6 ,,	236
Brienza (Italian) ..	5½ ,,	223
Matalla (Italian)	6 ,,	242
Ascoli (Italian)	5½ ,,	218
Gran sasso (Italian) ..	3¾ ,,	153
Abruzzo (Italian) ..	5 ,,	195
Bagdad white	4¼ ,,	172
Chinese white	9¾ ,,	388
Chinese (golden yellow) ..	7 ,,	277
Chinese (cross yellow) ..	6¾ ,,	272

The following *chhit* of univoltine worms commonly reared in the Punjab is evidently average (ibid, p. 651).

	Chhit (Average).	No. in lb.
Var-Jaune (French)	9 *pons*	360
Cevenne (French) ..	7¾ ,,	310
Kashmere Cevenne	11 ,,	436

The following is the *chhit* of cocoons reared in Assam (ibid, p. 695).

	Chhit.	No. in lb.	
Sarupat (indigenous multivoltine) ..	$19\frac{1}{2}$ *pons*	780	Ordinarily reared.
Barapat (indigeneous univoltine) ..	15 ,,	600	
French Univoltine × Assam ..	10 ,,	400	Experimental.
Japanese Bivoltine	$7\frac{3}{4}$,,	300	
French Univoltine (yellow) ..	7 ,,	275	
French Univoltine (white) ..	$6\frac{1}{4}$,,	250	

If the *chhit* is correctly noted on the third day of spinning in summer and fourth day in cold season and if the cocoons reel properly an approximate correlation is observed to exist in the case of the good Nistid and Nismo cocoons in Bengal for *tana* quality silk as shown in the following statement. Such correlation can be noted in the case of all cocoons. At present this is the guide of filature owners in making purchases of cocoons. The rearers note the *chhit* and the filature owners verify and accept their statement.

Chhit.	No. of *kahon* per md. of green cocoons.	Raw silk expected.		
		Seers	lbs.	Rendita.
16 *pons*	40	$2\frac{1}{4}$	4·5	18·2
14 ,,	35	$2\frac{1}{2}$	5	16·4
12 ,,	30	$2\frac{3}{4}$	5·5	14·9
10 ,,	25	3	6	13·6
8 ,,	20	$3\frac{1}{4}$	6·5	12·6

For the better quality re-reeled raw silk the rendita has to be increased by 2.

The above yield of raw silk correlated to *chhit* is to be taken as approximate. Variations actually observed in the Peddie Reeling Institute, Malda in the case of different cocoons in different seasons are given below (see VI) and it will be observed that this method of testing cocoons is not as reliable as ordinarily supposed. Besides frequently the rearers give a wrong *chhit* in order to gain a greater weight and thus a higher price for their cocoons.

II. *As judged by silk content* :—The proportion of the weight of the silky shell to the weight of the green cocoon including the pupa is frequently taken to judge the quality of cocoons. In this respect the multivoltine cocoons do not compare badly with the univoltine ones as will be seen from the following figures. The univoltine cocoons actually do not show as much superiority in silk content as in *chhit*.

Kind of cocoons.	Percentage of silk content.	
1. *Multivoltine*		
Pure Mysore ..	12·3	Written Evidence, Indian Tariff Board, 1940, p. 102.
Mysore × Chinese Univoltine F_1 ..	13·2	
Mysore × Chinese Bivoltine F_1 ..	13·7	
Mysore × Japan Univoltine F_1 ..	14·1	
Mysore × Japan Bivoltine F_1 ..	14·6	
Mysore × French Univoltine F_1 ..	13·2	

The above figures are evidently the best observed. Silk content in the case of multivoltine races varies in different seasons along with the *chhit*.

Records of the Biological Research Officer, Bengal Sericultural Department show the following variations during the period of July, 1941 to June, 1942 of which the temperature records are given in section 15.

Race.		Percentage of silk content.
Old races	Nistari	12·5 to 13·6
	Chotopolu	12·2 to 13·5
New fixed hybrids	Nistid	12·5 to 13·6
	Nismo	12·5 to 14·0
	Itan	13·0 to 13·8
Japanese univoltine turned multivoltine locally.	K. Nitchi	12·3 to 13·3

The above figures are not the best observed but of particular lots carried through the seasons of this period at Berhampore. The hybrids show silk content up to 14·6 per cent.

2. *Univoltine :*—Similar figures for the races reared in Kashmir and Jammu are not available. The following figures are of univoltine races maintained and reared in Mysore and are evidently the best observed as in the case of Mysore multivoltines above.

Name.	Percentage of silk content.	
Chinese Univoltine	14·3	Written Evidence, Indian Tariff Board, 1940, p. 102.
Chinese Bivoltine	13·1	
Japanese Univoltine	14·6	
Japanese Bivoltine	14·2	
French Univoltine	13·2	

The following figures are for the cocoons reared in foreign countries :—

In France, pure univoltine races	14·0—14·6	(ibid, p. 177-8).
In Italy, pure univoltine races	13·0—15·8	
In Italy, F_1 crosses	11·9—15·6	
In Japan, spring cocoons, mostly F_1 crosses	14·0—17·0	
In Japan, autumn cocoons mostly F_1 crosses	12·0—16·0	

The relationship of silk content in cocoons with yield of raw silk from them is indicated under Reelability Index below.

III. *As judged by filament length :*—The length of the reelable filament from the cocoon is an important factor of its quality. Raw silk is made up of these filaments joined end to end. The approximate lengths of filaments observed in different races are shown below :—

Multivoltine races (Race of worms).	Filament length in yards.
Nistari of Bengal	250—450
Chotopolu of Bengal	250—350
Po of Burma / Bulu of Bengal / Pat of Assam	200—300
Mysore race of Mysore and Madras	250—450
Assam Sarupat (Multivoltine)	290
Assam Barapat (Univoltine)	375
Univoltine races—Baropolu (white) of Bengal	250 to 400 yards.

Italian French Chinese and Japanese races	Reared in Kashmir, Jammu and the Punjab. Also reared in Mysore, Madras, Assam and Bengal for experimental purposes and for production of F_1 crosses.	500 to 1,000 yds. the length varying in the case of different races.

Fixed multivoltine hybrids introduced into Bengal.	Nismo, yellow and white ..	550 to 800 yds.
	Nistid, yellow and white ..	500 to 750 yds.
F_1 cross—	Japanese races male × Mysore races female introduced in Mysore and Madras.	500 to 750 yds.
	Japanese, Italian and French races, male × Nistari, Chotopolu, Nistid and Nismo female tried in Bengal	600 to 800 yds.
	French univoltine × Assam Sarupat reared in Assam	..565 yds.

IV. *As judged by denier i.e. thickness of filaments* :—In the case of the univoltine races the filaments are usually thin at the beginning, then they thicken and again become gradually thinner towards the end. In the case of the multivoltine worms they gradually become thinner from beginning to end.

The following figures show deniers of filaments of univoltine races reared in Jammu and Kashmir. They are apparently of the thick places :—

		Denier.	
Reared in Jammu—	European yellow ..	.. 3	Written Evidence, Indian Tariff Board, 1940, p. 214 and p. 239 and p. 651.
	Chinese golden ..	.. 2·5	
	Chinese white	2·25	
Reared in Kashmir—	French races ..	.. 2·25—2·46	
	Italian races ..	.. 2·34—3·16	
	Bagdad white ..	.. 2·87	
	Chinese races ..	.. 2·25—2·64	
Reared in the Punjab—	French univoltine ..	.. 2·35—3·17	

The following figures recorded by D. C. Sarkar give an idea of the variation in thickness of filaments of several races reared in Bengal (Papers presented at the 1st All-India Seri. Conf., 1939, p. 131).

Race.		Denier of filament.		Thickness in $M=\frac{1}{25000}$ inch.	
		Max.	Min.	Max.	Min.
Old indigenous—	Nistari ..	1·8	1·2	24·0	14·0
	Chotopolu	2·2	1·6	29·1	16·5
Hvbrids	Nistid ..	2·1	1·3	33·0	14·2
	Nismo ..	2·5	1·4	35·6	16·2
	Itan ..	2·3	1·5	36·2	15·6
Japanese turned multivoltine locally—	K. Nichi	1·8	1·3	29·4	17·5

The denier of the filament is also an important factor in the quality of the cocoon. A particular denier of raw silk is obtained by combining a lesser number of thicker filaments than thinner ones.

V. *As judged by Reelability Index* :—The length of the reelable filament and its denier (thickness) really contribute to the yield of raw silk from cocoons. The percentage of weight of the reelable filaments to that of the silky shells is therefore taken as reelability index and the higher this index the better the quality of cocoons as regards yield of raw silk. This index varies in the case of multivoltine worms with seasons.

The following from the Bengal Biological Research Officer's records gives an idea of the variations of reelability index during the period from July 1941 to June 42 of successive generations of the same lots of the abovementioned six races under IV reared during the period. Twentyfive cocoons were reeled individually in the laboratory with a hand reeling machine.

July, 1941.

1. Race of worms	Nistari.	Chotopolu.	Nistid.	Nismo.	Itan.	K. Nichi.
2. Average weight of shells						
in grams ..	·096	·096	·112	·112	·108	·108
in grains ..	1·48	1·48	1·72	1·88	1·82	1·82
3. Average percentage of silk content	12·5	12·8	12·5	12·6	13·0	12·3
4. Average filament length ..	351	319	503	465	518	438
5. Average weight of the reelable filament						
in grams ..	·061	·054	·098	·086	·096	·078
in grains ..	·94	·83	1·51	1·32	1·48	1·20
6. Reelability index	63·5	58·1	87·7	70·2	81·3	72·2

August-September, 1941.

1. Race of worms	Nistari.	Chotopolu.	Nistid.	Nismo.	Itan.	K. Nichi.
2. Average weight of shells						
in grams	·096	·096	·116	·124	·118	·112
in grains	1·48	1·48	1·78	1·91	1·82	1·72
3. Average percentage of silk content	12·5	12·8	12·6	12·8	13·1	12·3
4. Average filament length	365	322	527	515	520	507
5. Average weight of the reelable filament						
in grams	·06	·06	·098	·098	·096	·085
in grains	·92	·92	1·51	1·51	1·48	1·31
6. Reelability index	62·2	62·1	84·8	79·0	81·3	76·1

September-November, 1941.

1. Race of worms	Nistari.	Chotopolu.	Nistid.	Nismo.	Itan.	K. Nichi.
2. Average weight of shells						
in grams	·092	0·1	·116	·156	·122	·148
in grains	1·41	1·54	1·78	2·40	1·88	2·28
3. Average percentage of silk content	13·1	13·1	12·8	13·6	13·3	13·3
4. Average filament length	384	337	530	655	562	622
5. Average weight of the reelable filament						
in grams	·065	·07	·098	·124	·102	·12
in grains	1·00	1·08	1·51	1·91	1·57	1·85
6. Reelability index	70·9	70·0	84·8	79·5	83·5	81·1

November, 1941-*January*, 1942.

Race of worms	Nistari.	Chotopolu.	Nistid.	Nismo.	Itan.	K. Nichi.
Average weight of shells in grams	·09	·10	·136	·138	·124	·136
in grains	1·38	1·54	2·09	2·12	1·91	2·09
Average percentage of silk content	12·5	13·3	13·4	13·3	13·4	13·1
Average filament length	333	342	568	624	517	596
Average weight of the reelable filament in grams	·06	·07	·112	·12	·105	·115
in grains	·92	1·08	1·72	1·85	1·62	1·77
Reelability index	66·6	70·1	82·3	87·2	84·8	84·6

January-March, 1942.

Race of worms	Nistari.	Chotopolu.	Nistid.	Nismo.	Itan.	K. Nichi.
Average weight of shells in grams	·09	·1	·112	·152	·124	·124
in grains	1·38	1·54	1·72	2·33	1·91	1·91
Average percentage of silk content	12·4	13·3	12·6	14·0	13·4	12·5
Average filament length	318	339	508	650	525	516
Average weight of the reelable filament in grams	·06	·07	·095	·124	·106	·098
in grains	·92	1·08	1·46	1·91	1·63	1·51
Reelability index	66·6	70·1	84·8	81·9	85·3	79·0

March-April, 1942.

Race of worms	Nistari.	Chotopolu.	Nistid.	Nismo.	Itan.	K. Nichi.
Average weight of shells in grams	·1	..	·136	..	..	·095
in grains	1·54	..	2·09	..	..	1·46
Average percentage of silk content	13·1	..	13·6	..	..	12·17
Average filament length	368	..	579	..	..	428
Average weight of the reelable filament in grams	·065	..	·108	..	..	·078
in grains	1·00	..	1·66	..	..	1·2
Reelability index	64·9	..	79·4	..	..	82·1

April-May, 1942.

1. Race of worms	Nistari.	Chotopolu.	Nistid.	Nismo.	Itan.	K. N
2. Average weight of shells						
in grams	..	·076	·124	·12	·13	·
in grains	..	1·17	1·91	1·85	2·0	1·
3. Average percentage of silk content	..	12·2	13·4	12·5	13·6	12
4. Average filament length	..	317	464	497	486	421
5. Average weight of the reelable filament						
in grams	..	·054	·098	·1	·11	·
in grains	..	·83	1·51	1·54	1·69	1·
6. Reelability index	..	70·9	79·0	83·2	84·5	85·

May-July, 1942.

1. Race of worms	Nistari.	Chotopolu.	Nistid.	Nismo.	Itan.	K. Ni
2. Average weight of shells						
in grams	·108	·076	·124	·122	·118	·
in grains	1·66	1·17	1·91	1·88	1·82	1·
3. Average percentage of silk content	13·6	12·7	13	13·1	13·1	12
4. Average filament length	365	314	436	506	474	416
5. Average weight of the reelable filament						
in grams	·065	·06	·085	·102	·098	·
in grains	1·0	·92	1·31	1·57	1·51	1·
6. Reelability index	62·2	78·2	68·5	83·5	82·9	83·

No figures regarding denier of filaments of the races reared in Mysore is availab From the above figures it will be evident that percentage of silk content conveys no idea the actual quality of cocoons regarding their yield of raw silk. On the other hand weig of the silky shell and the reelability index i.e. percentage of the reelable filament to th weight of the silky shell is the important item. The reelability index should be near abo 80. In actual reeling *en masse* so much percentage cannot be realised; what can expected is shown under rendita below.

VI. *As judged by Rendita* :—The weight of green cocoons required to produce a giv weight of raw silk is called *rendita*. This can be determined for a lot by actually reeling sample quantity. At least $1\frac{1}{4}$ seer or $2\frac{1}{2}$ lbs. of cocoons should be reeled and rendi determined. This is the most reliable method of determining the quality of cocoons. Th test should be carried out by actually reeling the quality and kind of raw silk intended be produced from the cocoons concerned. Rendita of the same kind of cocoons is differe according to the kind of raw silk produced. Thus with Nistari and Chotopolu cocoons Bengal the rendita was as follows in country *charkha* (Written Evidence, Indian Tar Board, 1940, p. 372, and p. 475).

Bengal *Tana* (i.e. 1st quality for warp)	18·4
Bengal *Bharna* (i.e. 2nd quality for weft) of different qualities	14·6 ; 15, 14·2 ; 12
Bengal *Ghora* (coarse silk)	9·5
Mysore *Charka* silk, No. 1	18
No. 2	15
No. 3	12

The rendita of the univoltine cocoons reared in Kashmir and Jammu is as follows :— Vritten Evidence, Indian Tariff Board, p. 213 and p. 222).

		Jammu.		*Kashmir.*
		European × Chinese yellow.	Bagdad white.	(Average of all cocoons)
1933–34	..	14·4	18	12·6
1934–35	..	13·1	15	13
1935–36	..	12·6	17·5	12
1936–37	..	13	16·2	12·5

The rendita observed in Mysore Government filature is as follows (ibid., p. 115) for ;/15 denier silk evidently from Mysore and F_1 cross cocoons.

1932–33	..	20·5
1933–34	..	18·3
1934–35	..	16·4
1935–36	..	16·7
1936–37	..	15·9
1937–38	..	15·9

The following figures are from the records of actual reeling experiments in the Peddie eeling Institute, Malda for the different races of worms now reared in Bengal. In the atement for facility of comparison other data are included in order to find out the relamship of (a) *chhit* with rendita, (b) percentage of silk content on green weight of cocoons ith rendita and (c) silky shells of the cocoons with rendita.

The only constant factor in the cocoons is the silky shell which if not artificially wetted as practically a constant weight in the season in which the cocoon is reared. The weight the pupa which forms a factor for determining *chhit* and silk content is variable and ecreases with age from day to day. In the following statements the results stated are of speriments under commercial reeling conditions with cocoons purchased from village rearers different seasons in lots varying from one maund to about 15 maunds (over 1,200 lbs.). ae *chhit* is on green weight as stated by the rearer and therefore cannot be taken as very curate in all cases.

The silk content i.e. percentage of the weight of silky shells to the green weight of the coons is also not quite accurate and the figures under columns 5 (rendita) and 6 umber of silky shells in $\frac{1}{8}$ tola) and 8 (waste) are actuals as obtained.

The number of silky shells going to $\frac{1}{8}$ tola weight (weight of a two anna or one-eighth pee silver coin) is obtained in the following manner. The cocoons in the lot are thoroughly xed up and a handful of the cocoons is then picked up and sorted as follows. The best e are picked and placed in five different places. The next best five are picked and tributed in the five lots and this is contained until each lot has 20 cocoons. An average nple lot of 20 cocoons is thus obtained, which are cut and weighed in grains and the mber of shells going in 22·5 grains i.e. $\frac{1}{8}$ tola found out.

The expected rendita from calculation is obtained in the following manner. The mber of shells going in $\frac{1}{8}$ tola is observed to indicate the number of *kahon* of cocoons quired to produce one seer of silk. This number converted to *pon* and divided by *chhit* ves the expected rendita. It will be observed how very near the expected rendita comes the actual rendita obtained. This affords a fairly reliable method of judging the quality cocoons as regards yield and it will be fairly accurate if the *chhit* is fairly correct and nilarly the weight of dry shells and when the cocoons are free from reelability defects.

Thus in the rainy season *bhaduri* crop the cocoons often become *gazla* and do not reel l and rendita necessarily varies widely from the expected figure. It will be observed

from the statement that neither *chhit* nor silk content gives such a reliable method testing cocoons for yield as the number of empty shells going in ⅛ tola and this metho evidently applicable to all kinds and races of cocoons.

Results of reeling in Peddie Reeling Institute

Nistari cocoons.

1 Serial No.	2 Season	3 Chhit	4 Silk content %	5 Actual rendita	6 No. of shells in ⅛ tola	7 Expected rendita (calculated)	8 Waste %
47	*Chaitra*	23	12	24·3	34·6	24	106·8
48	,,	17	11·8	21·9	25	23	81·8
49	*Baisakhi*	18	11·3	19·2	21·4	19	71·7
50	,,	21	11·8	17·1	22·5	17·1	73·4
51	,,	18	11	17·9	20·4	18·1	60·9
53	*Jaistha*	17	11·1	20·8	19·5	18·4	97·7
78	*Baisakhi*	15·9	11·2	16·39	16·9	16·8	63·6
79	*Jaistha*	20·2	11·6	20·6	21·4	17	92·1
88	*Chaitra*	20	10·4	22·3	23·6	19	82·3
89	*Baisakhi*	15	9·7	21	19	20·5	50
55	*Bhaduri*	18	10·1	22·2	21·9	19·5	115·1
56	,,	18	12·3	18·8	18	16	87·1
57	,,	19	13·7	36·1	17·3	16	243·4
58	,,	16	11	21·9	18·3	18·2	109·5
80	,,	19·2	11·1	42·4	21·4	17·8	200
82	,,	17·2	9·8	23·6	21·9	20·4	98·7

Nistid cocoons yellow.

1 Serial No.	2 Season.	3 Chhit.	4 Silk content %	5 Actual rendita	6 No. of shells in ⅛ tola.	7 Expected rendita.	8 Waste %
46	*Chaitra*	16	11·4	19·8	17·3	17·25	77·2
64	*Agrahan*	12	12	15·9	12·8	17	66·6
72	*Maghi*	12·7	10·6	16·9	15	18·8	46·4
76	*Chaitra*	13·1	10·3	16·36	16·3	19·8	48·7
83	*Agrahan*	12	11·8	18	12·7	16·9	58·3
86	,,	12·4	9·3	18·3	17·3	21·2	51·9
87	*Chaitra*	16	8·9	23·8	22·6	22·5	63·3

Nistid white cocoons.

45	*Chaitra*	17	12·12	16·2	17·5	16·2	66·6
61	*Agrahan*	12	12	13·7	11·5	15·3	45·1
11	*Maghi*	11	10·5	16·5	20·75	17·5	53·1
73	,,	11·1	10·7	16·4	12·75	17·5	47·1
75	*Chaitra*	11·3	11·6	14·8	12·75	18	44·4
84	*Agrahan*	9·5	10·8	17·4	10·75	18·1	51·6

Nismo yellow cocoons.

62	*Agrahan*	11·5	10·8	15·2	13	18	47·1
66	,,	11	12·9	13·1	10·5	15·6	45·5
69	,,	13·3	12·7	19	14·5	17·4	71·3
74	*Chaitra*	15·1	10·4	14·9	13·5	14·2	46·7
85	*Agrahan*	11·6	11·4	18·75	12·5	17·5	64·5

VII. *As judged by reelability defects of cocoons.*—Generally a small percentage of the cocoons spun by a lot of worms becomes defective for purposes of reeling.

(1) Dead cocoons are those in which the worm dies before pupation and in rotting soils the silky layers.

(2) Flimsy cocoons are those in which the silky shell is thin and flimsy hardly yielding any reelable filament.

(3) Dupion or double cocoons are those in which two worms spin a single cocoon together. It is a characteristic of foreign univoltine worms. The existing multivoltine worms or the Bengal univoltine Baropolu worms do not spin double cocoons. Such cocoons cannot be reeled into good uniform raw silk as their filaments are entangled.

(4) Spotted cocoons are those which are not soiled as in (1) but show a brown or black spot on account of some secretion from inside or outside for instance when soiled by excreta of moths.

(5) Crushed cocoons are those which get crushed under pressure. Dead, spotted and crushed cocoons require to be boiled longer in order to be reeled. Defective cocoons if mixed with healthy cocoons not only interfere with reeling but go into waste.

(6) *Gazla* cocoons i.e. cocoons spun under highly humid conditions when it rains continuously. The whole lot of such cocoons do not reel properly to yield good raw silk.

(7) Cocoons damaged by moths cutting out or cut by rats or pierced by ants and the parasitic fly maggots do not reel and require to be separated out. Otherwise they interfere with reeling of good cocoons.

(8) Reelability of cocoons is observed to be affected by seasons of rearing, subtle effects of climate and food of the locality of rearing and breed of the worm. Therefore cocoons reared in spring, summer, autumn, and winter or produced in a particular locality or of different breeds are better reeled separately.

Testing of reelability of cocoons is best done by practically reeling a sample lot about $2\frac{1}{2}$ lbs. or $1\frac{1}{4}$ seers by weight. Dr. Inouye of the Ueda Sericultural College, Japan, showed that the fluorescence of cocoons exposed to the light of quartz or mercury vapour lamps indicated their reeling quality. Thus white cocoons giving yellow fluorescence reeled well, that is, were reeled with ease in the shortest possible time and yielded larger proportion of raw silk and less waste than white cocoons with violet fluorescence which reeled badly and those with fluorescence intermediate between yellow and violet gave intermediate results. Yellow cocoons with bright yellow fluorescence reeled well but badly when the fluorescence was dark violet.

VIII. *How to judge the quality of cocoons as regards yield and evaluate and pay for them.*—It will now be evident from the foregoing discussion that each lot has to be judged separately on its own merits and if cocoons with defective reelability can be sorted out a fair idea can be formed for quality as regards yield.

The lot offered for sale by a rearer should be thoroughly mixed up after sorting of defective cocoons. The weight of the lot is then taken and the weight converted into *kahon, pon* and *gonda* by taking one or half or quarter seer by weight and counting them.

Then take an average sample of cocoons, if possible according to the method described under sub-section (VI) above and cut them open with the help of a razor blade and reject the pupae and the last larval skins and see how many clean and dry empty shells go to weigh 22·5 grains or weight of a silver Indian two-anna coin. This weighing is best done on a balance or in a fairly sensitive goldsmith's scale (*Nikti*). The number of empty shells thus found out indicates the number of *kahon* of cocoons required to yield one seer silk.

The price A obtainable for a seer of silk being known and the cost B of all items for procuring, reeling and marketing the resultant raw silk plus profit being known, the price C of the cocoons required for one seer silk can be easily found out.

Thus if A = Rs. 60
B = Rs. 15
C = A—B = Rs. 45.

The price for the whole lot of cocoons can be easily determined. If calculation by pound is desired half the number of shells going in $\frac{1}{8}$ tola will indicate the number of *kahon* required for producing one lb. raw silk.

This is fairly accurate especially in the case of cocoons up to 16 of which weigh $\frac{1}{8}$ tola yielding at the rate of 18 to 1. For inferior cocoons the proportion of waste will be higher and one, two and three *kahon* cocoons added respectively to lots going from 17 to 20, 21 to 23 and 24 to 28 cocoons in $\frac{1}{8}$ tola will be an approximate estimate. The above calculation holds good in the case of all cocoons produced in the dry season. For cocoons spun in the rainy season it is necessary to carry out actual reeling test as *gazla* cocoons do not reel and necessarily interfere with outturn of raw silk.

67. Treatment of cocoons before reeling.

Freshly formed cocoons taken out of the cocoonage can be reeled but in such cases only coarse thread is produced (see next section). For producing better threads the cocoons require to be dried. In practice in the case of large filatures cocoons are dried and stored and reeling is carried out gradually.

Univoltine cocoons can be dried and stored for any length of time and reeled whenever desired. Multivoltine cocoons show different characters in this respect. Thus such cocoons spun in the rainy season in Bengal i.e., when the atmosphere is humid, can be reeled after drying for production of fine raw silk without any further treatment. But when the atmosphere is dry from about October, November to April, May or June, the cocoons require to be steamed. Otherwise they do not reel well and impurities occur on the raw silk. A simple cocoon-steaming chamber used in Bengal by all filatures and known as *tondur* is illustrated in Fig. 62. It is a masonry dome with thick walls and masonry floor and is closed all round except for the small door seen in the illustration. Wood fuel is burnt inside to heat the structure and then the fire is removed and the inside watered profusely. Then baskets full of cocoons are put inside and the door closed with a plank. The cocoons are left there overnight or as long as necessary and then they are taken out and spread on shelves. Reeling of such steamed cocoons is carried out gradually.

FIG. 62—" Tondur " or cocoon steaming chamber (Explanation in the text)

Tondur has been practically found to be effective. Masonry steaming chambers can be devised with shelves for cocoons and steam from boiler can be driven into it.

Small quantities of cocoons are steamed in various ways on the same principle. Thus an earthen pot filled with cocoons and with a few sticks inserted in order to prevent the cocoons from falling out is placed upside down over boiling water in reeling basins. A basket of cocoons covered with a thick gunny cloth and similarly placed over boiling water also serves the purpose.

68. Reeling, coarse and fine.

The purpose of reeling is to extract the silk of the cocoon in a form capable of being used in the manufacture of various silken goods. Reeling may be broadly divided into (1) coarse, producing a coarse uneven thread, and (2) fine, producing "fine" thread of uniform thickness. Silk threads, whether reeled coarse or fine have their uses. Coarse threads however have limited uses being utilised in the manufacture of thick coarse articles woven on handlooms. Fine threads are in demand for articles of fine uniform texture and for use in power-looms. Coarse threads have necessarily a limited market while there is no limit to the demand for fine raw silk of uniform quality and the world market is open to it. A part of the cocoons however well reared becomes defective which can be dealt with only in coarse reeling. Therefore, however highly sericulture and reeling may be developed in any place along with fine raw silk of uniform quality, a part of the produce is bound to be coarse. There must be arrangement for both fine and coarse reeling, though the latter will be on a much smaller scale than the former especially when the industry is well organised and developed. All primitive reeling was coarse. Improvement of machinery and methods brought about fine reeling which is at present the main objective, coarse reeling being carried on for utilisation of defective cocoons as a bye-product of the main industry.

69. Machinery and methods of coarse reeling.

The most primitive method and appliances observed by the writer are in use by the Karens in the Leiktho Hills of Burma and illustrated in Fig. 63. An oven is improvised

FIG. 63—Reeling practised by the Karens in Karen Hills, Leiktho, Toungoo district, Burma.

with three stones and the cocoons are boiled in an earthen pot on this oven and manipulated with a pair of iron tongs. The coarse thread pulled with hand out of the silky layers of the boiling cocoons passes through a hole in the middle of a horizontal flat bamboo strip above the mouth of the pot and then over and round a bamboo wheel, both the strip and the wheel being attached to two bamboo uprights standing astride the mouth of the pot and secured at their top ends to a beam in the shed. The thread is pulled with the left hand and placed on a bamboo tray, being afterwards rolled with hand into a ball. These balls are sold.

A slightly more advanced method is followed by the Yabeins in Prome district in Burma, a round wooden block on an axle being turned by the left hand of the reeler to wind the thread on it. The thread is then unwound on a swift and made into a hank (Fig. 64). The primitive machine used in Japan of practically similar construction was the frap reel consisting of a cylindrical piece of wood about 2 ft. long and 5 inches in diameter on an axle supported on a stand about 6 inches high. The reeler gathered the filaments of the cocoons boiled in a pot on an oven, twisted them between her palms and wound the thread on the wood by frapping it with the hand. It is no longer in use.

FIG. 64—Reeling practised by the Yabeins in Prome district, Burma.

An improved form of the above was the hand reel (Fig. 65) consisting of a rectangular reel of about 2½ ft. circumference and fitted on a stand. The reel was turned with the left hand to wind the thread on it. It is not in use now.

An improvement on the above is the sedentary reel illustrated in Fig. 66. In one form the reel is turned by the reeler with her left hand with two toothed wheels. In the form shown a wheel turns the reel with a belt and a pulley attached to the axle of the reel which has a circumference of about 1′-9″ to 2′. The cocoons are boiled on the pan and manipulated with the hand. The thread consisting of several filaments from the cocoons is passed over a V-shaped brass wire fixed on a piece of wood placed near the edge of the pan and then to a loop fixed to the top of a bamboo distributor which moves destributing the thread on the revolving reel. From the small reels the thread is then re-reeled on a large reel and made into hank. Usually a single thread is reeled at a time but in some forms of reel two threads are done. This machine is in use for reeling defective cocoons and double cocoons. In the case of double cocoons a small stiff brush is used to brush off the fibres from the surfaces of the boiled cocoons and feed them to the thread as it passes on to the reel.

Fig. 65—Primitive hand-reel of Japan. "Teguri-kikai" or hand-reel.

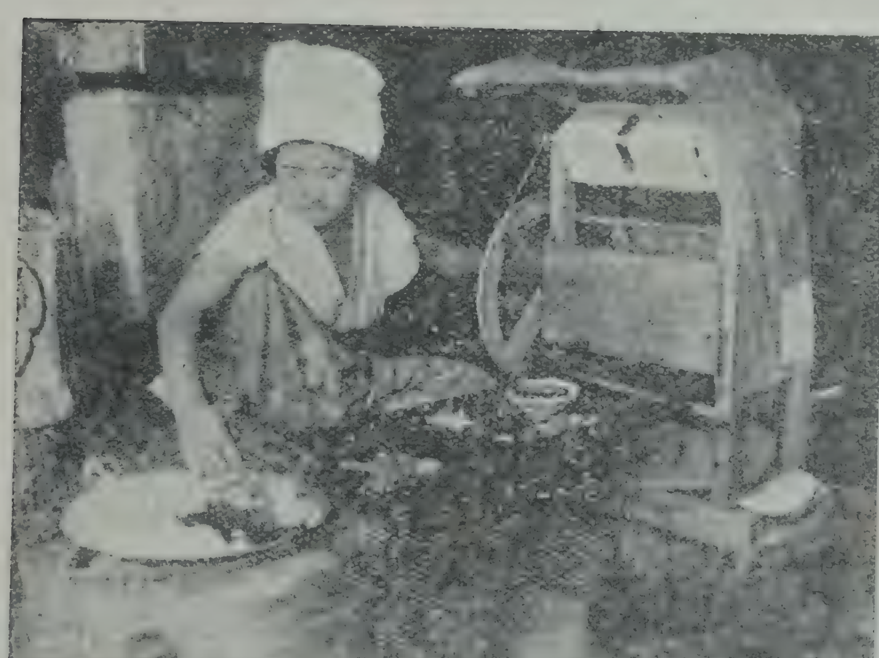


Fig. 66.—Sedentary reel of Japan. "Zaguri-kikai".

For reeling coarse silks, known as *ghora* silk in Bengal, the hand *charkha*, illustrated in Fig. 67 is used. The cocoons are boiled in a pan over an oven and manipulated with a stick. Two threads are reeled at a time and pass through holes in an iron strip placed near the edge of the pan. Distribution on the reel is effected by toothed arrangements at the ends of the sloping bar seen in the picture which moves the horizontal stick in front of the reeler to and fro. Machines in use in other places in India for coarse reeling are practically of the same type. *Ghora* is reeled from *gazla* cocoons. Sometimes the demand for *ghora* is so much that good cocoons are utilised for producing it.

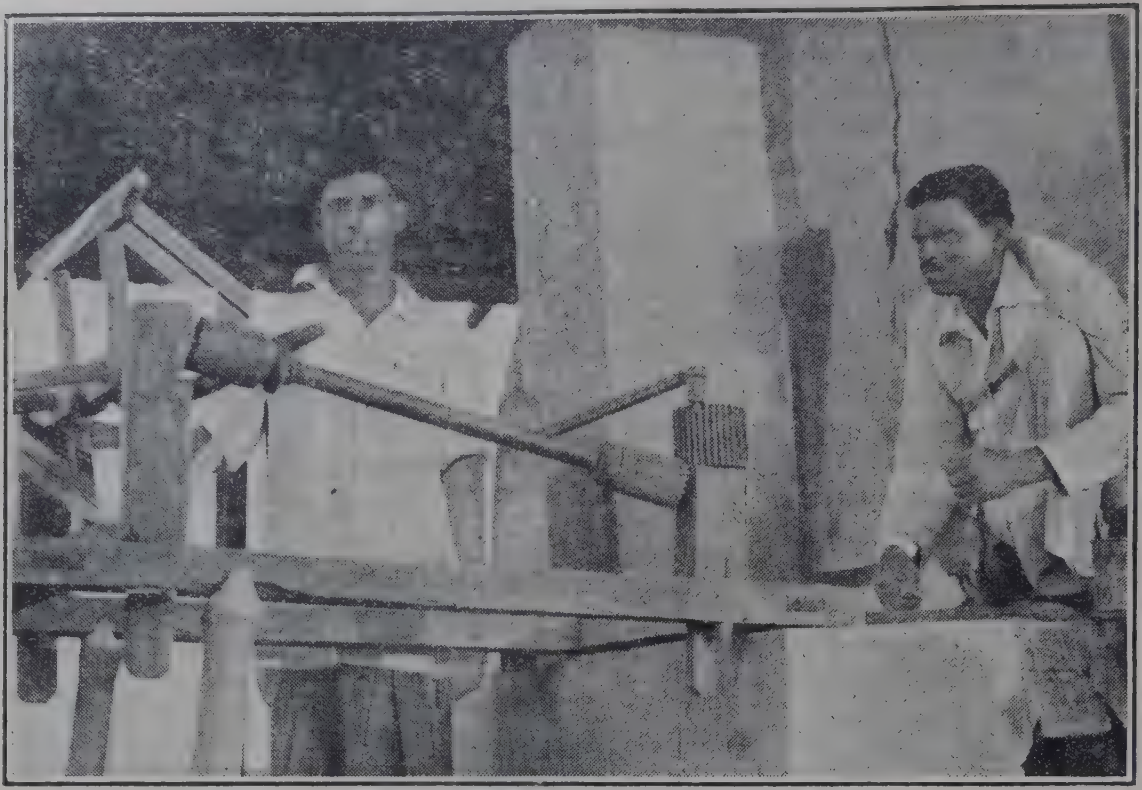


FIG. 67—Hand silk-reeling *charka* of Bengal.

In all the above forms of coarse reeling the entire contents of the silky shell of the cocoons are passed on to the thread which is often extremely coarse and contains parts of the pupa and other dirt. Coarse threads are of several qualities, some thinner than others and cleaner.

70. Machinery and methods of fine reeling.

The essentials of fine reeling are the following :—

(1) Only the reelable filaments of the cocoons are used in the manufacture of the thread, the unreelable outer and inner parts going into waste.

(2) A definite number of the filaments are passed into the thread so as to produce as far as possible raw silk of a uniform denier. The greater the uniformity of denier and the less the variation the better the raw silk.

(3) By far the largest proportion of the product of fine reeling is 13-15 denier or 20-22 denier and rarely above 28-32 denier. This fine thread is passed through a fine hole in the button (see Fig. 6) and is consolidated and rounded by croisure. There have been many devices to facilitate joining fresh filaments to the thread being reeled and consolidating the filaments by croisure.

For feeding filaments broadly speaking two methods are followed :—

(a) Where buttons are used the reeler actually throws with hand the filaments to be joined on the filaments running up.

(b) In the jette-bout system the thread passes through the hole of a vertical cylindrical metal tube at the lower end of which a wheel or rather disc with notched margin revolves. The filament to be fed is held against the margin of the revolving disc and gets united with the filaments already running up. In another method a spiral wire is added in place of the disc to a revolving tube. In a third method the filaments pass over a dent in a cross plate or between closely adjusted wires which rub off slugs, nibs, etc.

For croisure too two methods are followed :—

(a) In the chambon method the two threads being reeled are crossed and twisted over one another.

(b) In tavelette method each thread is twisted over itself after passing over two pulleys, after leaving the button or jette-bout.

(4) The thread is further required to be free from impurities and dirts and it should not break in unwinding.

It is in fine reeling that the four points mentioned under section 65 have their special application.

The best raw silk as pointed out by Rosenzweig, is the one that allows the highest speed on the loom. This condition is fulfilled if the uniformity of thickness of the thread is maintained. All defects are really speaking deviations from uniformity, defects interfering with uniformity. All the tests for quality of raw silk are directed to find out how far uniformity is maintained and what defects are present. If uniformity is good other defects including breakages in unwinding are found to be less than in an ununiform thread.

In order to ensure production of uniform raw silk Rosenzweig has enunciated the following rules to be observed in reeling.

1. The number of cocoon filaments passing on to the thread must be the same during the whole time of reeling.

2. The cocoons reeled together ought to be of the same race and of about the same size (small cocoons of even the same race have a shorter filament length than big ones).

3. The cocoon filaments must combine in such a manner that about half of the number are at the beginning or at the end while the other half are at the middle. (In the case of univoltine races the filament of the cocoon is thick in the middle and thinner at the beginning and towards the end it gradually becomes thinner and thinner. In the case of multivoltine cocoons the thinnness at the beginning is not so pronounced and the filament gradually gets thinner and in their case the rule has to be slightly modified to mean half from old and half from new cocoons).

4. The cocoon thread must be stretched to a straight line (otherwise loops may form).

5. The sericin must be sufficiently soaked (to allow the filament to come off easily).

6. The sericin must not be soaked too much (when tangled lumps of the filaments may come off).

7. The cocoons must be assorted according to their texture.

8. The right speed of reeling must be maintained. [The speed has to be adjusted according to the length of the filaments obtained from the cocoons to be reeled. Thus in the case of cocoons yielding say about 300 yards filament length three successive cocoons will have to be fed for one cocoon giving about 900 yards filament length. In order to facilitate feedings, the speed in the former case must be slower than in the latter cocoons. Generally speaking multivoltine cocoons of Nistari type (300-400 yards filament lengths) the speed should be about 100-120 yards per minute, for cocoons of hybrid Nismo type (500-600 yards filament lengths) about 140-160 yards and for superior univoltine cocoons (700-900 yards filament lengths) about 160-180 yards].

9. The stretched cocoon threads must be united and agglutinated by a concentric pressure (with proper and sufficient croisure).

10. The sticking together of the thread must be avoided, (this occurs especially when the thread rests on the reel arm and may be avoided by having re-reeling on reels with a grooved and rounded edge).

The practice of describing the denier or thickness or size of a raw silk as 13-15, 20-22 and so on is indicative of the inherent difficulty in manufacturing raw silk of a particular thickness. The thickness is maintained by feeding the thread with fresh filaments as those of the exhausted cocoons end. Unless the reeler is an expert one and unless he is always careful to feed at the correct moment there is bound to be variation in the thickness. In actual practice some variation is permissible. Thus in the case of 13-15 denier or average 14 denier raw silk the variation permissible is up to 16 denier on the thicker and 12 denier on the thinner side without depreciating the grade. Even this much of uniformity is possible to be maintained by careful supervision of reelers who are made to work at one place in filatures or factories.

71. Machines and methods in Japan.

Machinery for reeling high grade raw silk was devised in Italy and France. The Japanese Government introduced the European machinery and started a filature with it in 1870 for improvement of reeling in Japan. This machinery as well as methods have been modified in Japan. The principal modification is splitting the operation into actual reeling on small reels and then re-reeling the raw silk from the small reels on to large reels for standard hanks. In Europe the method still followed is to reel at once on standard reels and no re-reeling is practised. The reputation for quality of Japanese raw silk is to a very great extent due to re-reeling. Re-reeled raw silk is in demand everywhere. The best form of European machinery has the jette-bout system of feeding the filaments. The jette-bout is a rather complicated affair and difficult to maintain in order. In Japan the button is in practically universal use. It is very simple. It is only necessary for the reeler to be careful to feed one filament at a time.

The domestic or cottage reeling machine adapted from the European machinery and in use for fine reeling in Japan is a simple one, driven by the reeler herself with foot. The form in general use is illustrated on the right hand side in Fig. 68. A wooden box is used as oven. A peasant family maintains one or a few such machines at home and works them. Frequently a small capitalist advances cocoons and charcoal to owners of treadle machines, collects the small reels when full and carries out re-reeling at his own house. He pays remuneration for reeling. The machine can be worked with fixed masonry oven too as shown on the left hand side of the illustration. The product of the treadle machines cannot be expected to be uniform in bulk supply and is therefore not exported but utilised in Japan itself.

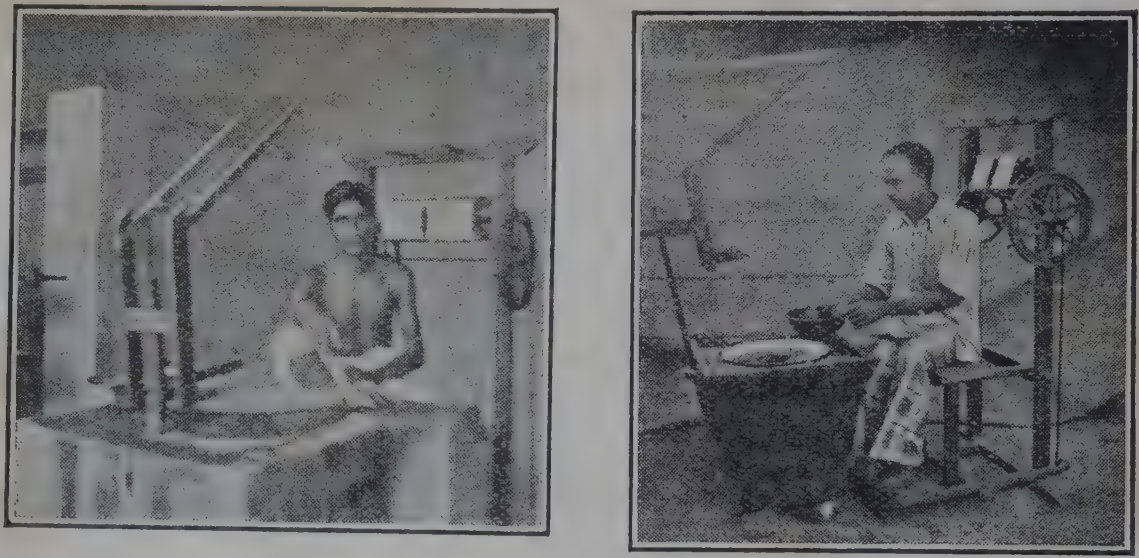


FIG. 68.—Treadle reeling machine. On the right the basin is heated by fire in a portable wooden oven. On the left a masonry oven.

Filatures are engaged in fine reeling and their products are exported to foreign markets but only with certificates of the Rawsilk Conditioning House. The products of coarse reeling, for instance, dupion silk, are also exported but on a limited scale and they are not required to pass through the Conditioning House.

In the filatures the reeling basins are heated with steam and the reels are turned by power, generally electrical. The reeling basins are of Chinaware (Fig. 69) fixed on platforms and connected with water and steam taps and outlets for waste water. In practically all machines the reels are small, 2 ft. in circumference (Fig. 70). When they are full they are taken to the re-reeling machine and the raw silk is re-reeled on large reels to make standard hanks 59″ in circumference (Fig. 71).

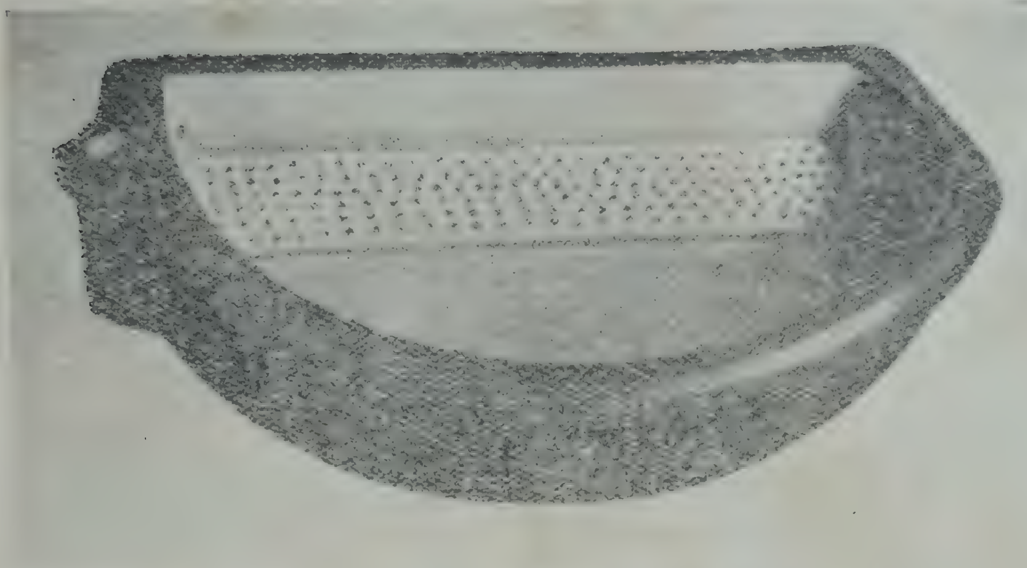


FIG. 69.—Chinaware reeling basin used in Japan. Common type of Chinaware reeling basin.

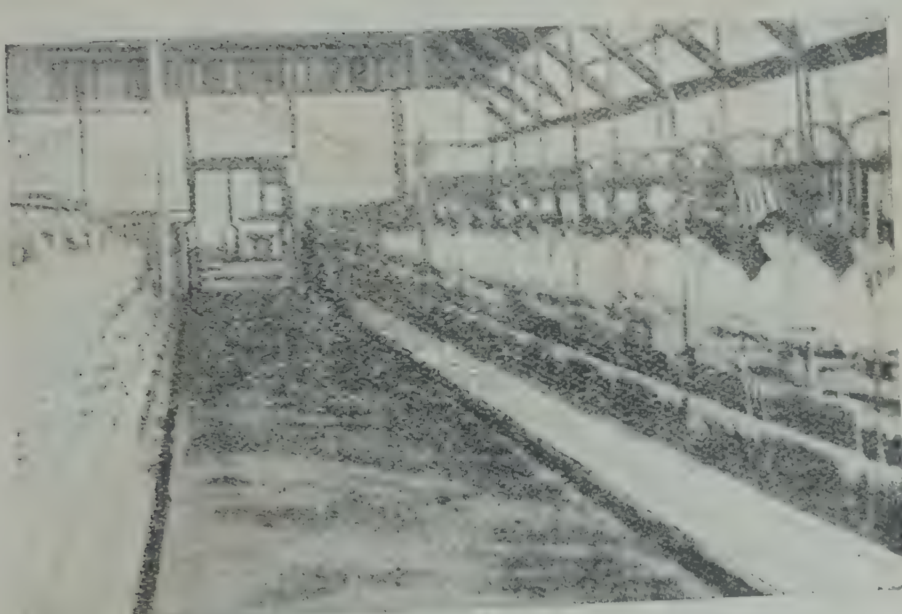


FIG. 70—Japanese filature The reeler girls at work sitting.

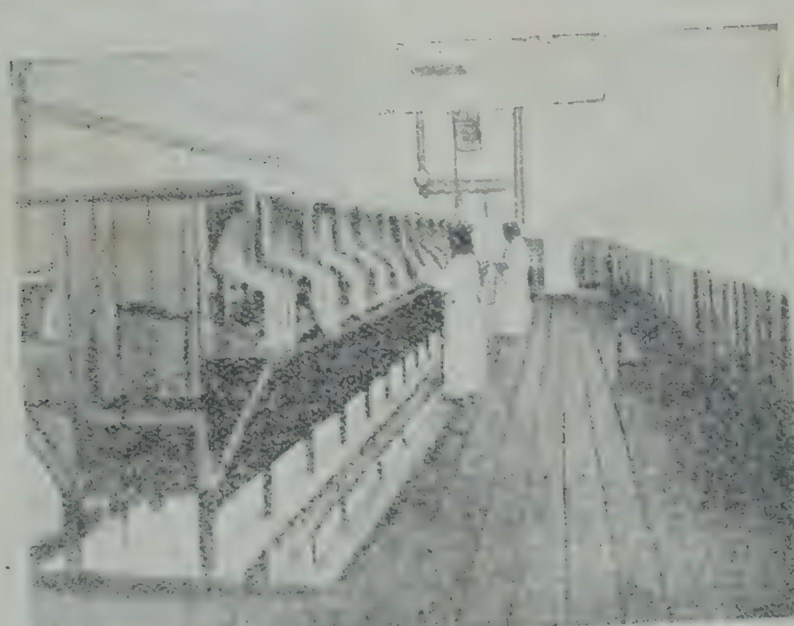


FIG. 71—Japanese re-reeling machine. The small reels from the reeling machines are placed on the ground on one end and the thread drawn off.

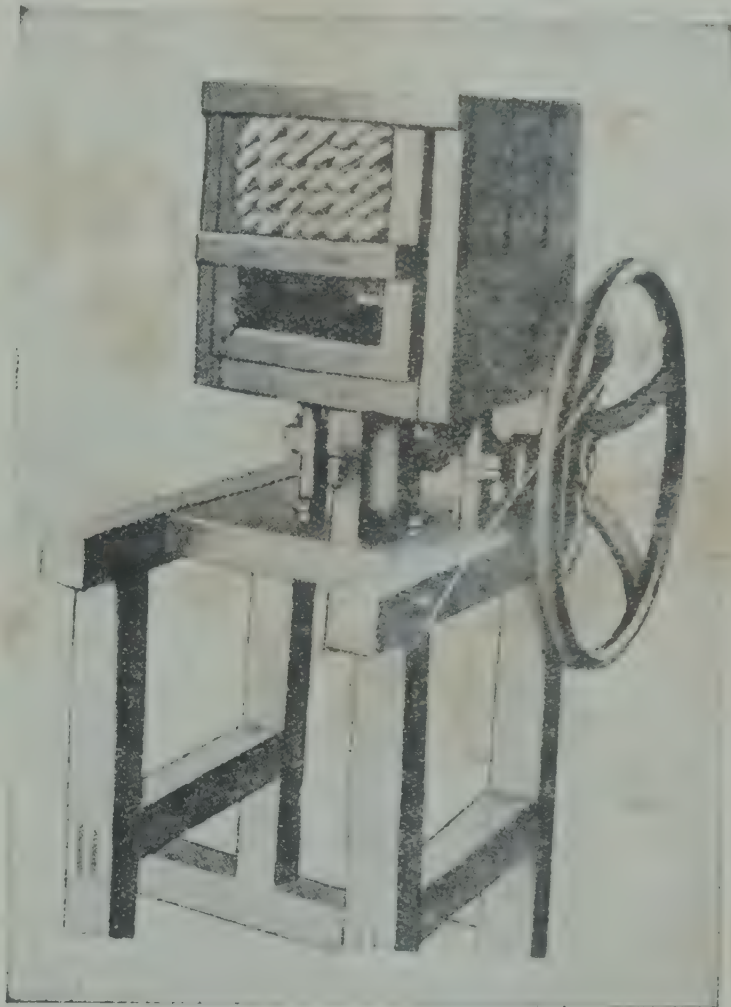
A record is kept of breakages in re-reeling with a simple breakage counter (Fig. 72) made with a pointer turning on a screw or nail in a circle with marks and divisions. A test skein 225 meters in length is also taken to find out the denier of the hank. All these are noted on a strip of paper accompanying the hank until the hank is finally incorporated in the book and bale. After re-reeling the hanks are neatly folded and twisted and folded into a convenient shape (Fig. 73), so as to be neatly accommodated in the book (Fig. 74).

Fig. 72—Simple breakage counter.

Fig. 73—Twisting the hanks of silk. A loose hank on top and 2 twisted hanks below.

Fig. 74—A book of raw silk.

A book of 13-15 denier raw silk contains 30 hanks each weighing about 2·4 oz. and therefore itself weighs about 4½ lbs. Thirty books go to make a bale. The book is arranged and pressed in a book-making box illustrated in Figs. 75 and 76. Each book is tied with several strands of cotton threads at three places, the label or chop of the brand is added and the whole is wrapped in tissue paper. The books thus packed are placed in a new linen bag called shirt which is sealed by the Conditioning House after examination and test. The bale in the shirt is covered with a strong mat and secured with ropes and is then ready for export.



Figs. 75 & 76—Book-making boxes.

72. Reeling machines in use in Bengal for fine reeling.

The East India Company introduced a type of cheap machine made of wood and with buttons and croisure which is still in use largely and was made use of by the European filatures. The machine is illustrated in Fig. 67. In one form it is made in a compact frame and placed on supports. In another form it is attached to two wooden uprights fixed into the ground. It is turned by a turner who also attends to joining breakages and cleaning dirt from the thread. Cocoons are boiled on earthen reeling basins with steam by the reeler himself, each basin being supplied with water and steam. Two threads are reeled at a time and the croisure is secured by crossing one thread with the other. The machines used in Bengal up to 1936 were practically wholly of this type. The same machine is used in coarse reeling, too, when the buttons are dispensed with.

A systematic attempt at improving reeling machinery and methods was undertaken with the starting of the Peddie Reeling Institute at Malda in 1937. An improved treadle

machine of Japanese type (Fig. 68) working on masonry ovens heated with wood fuel and a locally devised hand-driven re-reeling machine suitable for re-reeling the output of eight treadle machines in one operation were at first adopted and tried in this institute. A small model power-driven up-to-date Japanese reeling machine with separate basins for cooking cocoons with steam and re-reeling machine was also set up. Later on a hand-driven tandem reeling machine (Fig. 77) reeling from 8 to 12 or even 15 basins with one operation and similarly worked re-reeling machine (Fig. 78) now known as Ghosh Machines (after the writer's name) were devised. Ghosh Machines can be worked with ovens heated by wood fuel. They have now been adopted in small as well as large factories which heat their basins with steam.

FIG. 77—Ghosh Reeling Machine. The posts are of wood. Driving wheels on iron shaft.

Mr. B. B Roy, Officer-in-charge of the Bengal Government Rawsilk Conditioning House has mechanised the above machines and made them wholly of metal and added an electrical control for keeping the range of denier of the thread being reeled within limits, the machine stopping automatically if the denier goes above or falls below those limits. Reeling and re-reeling are done on the same machine with one operation. It is made in units of six basins and driven by a ½ H.P. motor. The working of the control however presupposes good cocoons, good practice and skill on the part of the reeler. This machine requires electric

power and it requires to be made with good metal and good workmanship. Otherwise they deteriorate very quickly and become difficult to work as has actually been the case in the first large factory fitted with it. Reeling and re-reeling on the same machine are also inconvenient. Reeling concerns have adopted the treadle machine on a small scale and Ghosh Machines extensively. The treadle machine is a cottage or domestic one and is best used in that way. Ghosh Machine is made mostly of wood with metal wheels, pulleys and shafts and reeling and re-reeling are carried out on different machines, which in small concerns are best driven with hand but can be driven with power. It is best suited to villages where no power is available.

FIG. 78—Ghosh Re-reeling Machine.

73. Machines in use in Kashmir and Jammu for fine reeling.

Reeling is entirely in the hands of the sericultural departments of these places. These departments are organised from the beginning mainly to carry out fine reeling in the State filatures. The filatures were at first fitted with locally manufactured wooden machines. A fire burnt down these filatures in 1913 with the exception of one. Italian machines were then imported at a cost of about Rs. 1,000 per basin. Recently before the present war Jammu imported such machines at a cost of about Rs. 500 per basin. Lately at Srinagar a simple filature with button system and without jette-bout and with cement

basins has been set up at a cost of about Rs. 162 per basin. It is reported that this filature does equally good work as the Italian ones.

74. Machines in use in Mysore and Madras for fine reeling.

Unlike Bengal and Kashmir where filature reeling had been in practice on a large scale Mysore carried on reeling on *charkhas* i.e. reeling machines of more or less old Bengal type as a domestic industry. The product of domestic reeling as in the case of treadle machines of Japan could not be uniform in bulk. In order to foster filature reeling the State started a filature with French machinery in 1922. A domestic reeling machine was devised and supplied to reelers at concession rates. It however did not prove successful. Filature reeling did not however commence before the starting of the Mysore Filatures Ltd. in 1938, at T-Narasipur in Mysore district. The reeling machine adopted here does reeling on standard hanks at once without re-reeling.

The remarks under Mysore apply to Madras. A filature was started at Kollegal with imported European machinery. New filatures have been recently started both in Mysore and Madras. The sericultural departments in both tried several domestic type machines.

75. Lines on which reeling requires to be developed.

The writer has had occasion to use the products of all types of reeling at present carried out in Bengal, Mysore, Kashmir and Jammu in connection with the manufacture of parachute components comprising fabrics for canopy, cords, tapes and sewing threads. Reeling machinery and methods are concerned with the following essential requirements in the raw silk which facilitate manufacture viz. (1) ease in winding without break or with as little break as possible, (2) uniformity of thickness, and (3) freedom from slugs and other impurities which stick to the thread.

Uniformity of thickness (size) requires skill and care on the part of the reeler in maintaining uniform number of filaments (ends) in the thread being reeled. Slugs, wastes etc. occur on the thread being reeled and they are due partly to the quality of the cocoons and partly to their treatment and cannot be wholly avoided. The practice is to pick them off from the hank after taking it off from the reel causing many breakages. If the hanks are not re-reeled after cleaning and breakages joined the winding quality of the silk is affected very much. Kashmir and Jammu silks, although reeled on good Italian machines and from univoltine cocoons which are by nature better than multivoltine ones, have been observed to be very poor in winding quality, the hanks breaking up to 40 to 50 times in winding. This is evidently due to absence of re-reeling. Re-reeled silks are decidedly superior in winding quality. Re-reeling is best done on a separate machine as is the universal practice in Japan. Ghosh Reeling Machine further provides reeling reels accommodating and spreading the thread on wide faces which permit cleaning of the impurities during the process of reeling.

Reeling should be accompanied with re-reeling; reeling and re-reeling are better done on separate machines allowing of proper attention being paid to both the operations separately.

Hanks should be standardised as regards circumference and weight and books and bales should be similarly standardised so that the raw silk produced may find access into international markets dealing with Chinese, Japanese and European raw silk. In this connection see section 76.

PART VI.

RAW SILK.

76. Properties of raw silk.

Natural gum :—The silk filament of the cocoon consists of fibroin or true fibre and sericin or gum covering the fibre. Cross section of a filament when magnified is more or less of the shape of the figure 8 with the circles somewhat compressed sideways at the extremities. The sericin causes the loops of the filaments to stick together in the cocoon. When the cocoons are boiled for reeling the gum is softened and partly dissolved allowing the filament to be pulled off. Loosened filaments of several cocoons are passed together to form the raw-silk thread. The sericin adhering to the filaments dries on exposure to air and causes the filaments to agglutinate and stick together in the thread. When the raw silk or goods manufactured with it are degummed by being boiled in soap or other alkaline solution, the sericin is dissolved and washed off. Raw silk loses about 18 to 30 per cent and in some cases more of its weight in this process. This percentage varies with different races of worms and also with places of rearing evidently depending on food, soil, climate, etc. Silk being a costly article this loss determined by boil-off test is important in the raw silk trade. The following statement shows the results of boil-off tests as carried out in the Bengal Rawsilk Conditioning House in the case of samples from different places.

Raw silk from	Average boil-off loss, per cent	Range of percentages of loss in the samples tested.	Remarks
Kashmir ...	25·7	24 to 29	Reared in altitudes about 5,000 ft.
Jammu ...	22	17 to 26	Reared in altitudes varying from 1,000 to 5,000 ft.
Bengal ...	20·8	18·7 to 23·1	Reared in plains below 150 ft.
Mysore ...	22·9	21·6 to 24·2	Reared in altitudes from about 2,500 to 3,000 ft.
Japan ...	18·4	18 to 18·8	

A more reliable implication of boil-off loss is obtained from the reports of the Bombay Silk Mills Ltd., Colaba Road, Bombay, published in the Written Evidence, Indian Tariff Board, on *Silk Industry*, 1940, p. 995 *et seq*. This mill used exclusively Kashmir raw silk for four years, 1932 to 1936 and then Japanese raw silk. The boil-off losses observed were for :

Japan white	22 per cent.
Japan yellow	24 per cent.
Kashmir white	25 per cent.
Kashmir yellow	30 per cent.
Kashmir yellow inferior	33 per cent.

Supposing both Japan yellow and the best Kashmir yellow selling at Rs. 5-12-0 per lb., the difference in the cost of production of fabric weighing 1 lb. owing to this difference in boil-off losses is indicated below:—

	Kashmir yellow.	Japan yellow.
Raw silk required ...	1 lb. 6·8 oz.	1 lb. 5·3 oz.
Value @ Rs. 5-12-0 ...	Rs. 8-3-0	Rs. 7-10-8
Boil-off loss ...	30%	25%

Therefore at the same price it is cheaper to use Japan silk.

A very convincing concrete instance of the importance of boil-off loss has been observed recently. Raw silk reeled according to re-reeling methods now adopted in Bengal in the Jangipur filature of Messrs Maniruddin Ahmed & Co. and marketed as Lotus Brand, has been fetching much higher price than Kashmir silk in Benares especially for the reason that for every 10 lbs. of this silk about 11½ lbs. Kashmir silk is required to produce particular weights of finished fabrics.

When the raw silks from different countries come into competition the boil-off loss has got to be considered. In the case of psatlee silks of China contracts include a condition that if there be more than 21% boil-off loss the purchaser has to be compensated.

Variations of boil-off losses according to seasons of rearing observed in the Conditioning House in the case of raw silk from the cocoons of the multivoltine Nistari race of Bengal are as follows :—

Raw silk from *Sravoni* (August) crop of cocoons	23·1%
Raw silk from *Kartiki* (October) crop of cocoons	20·4%
Raw silk from *Aghrani* (December) crop of cocoons ...	18·7%

The Biologist's record in the Bengal Sericultural Research Station shows the following variations in gum percentages in the filaments of cocoons of worms under rearing during the year (July, 1941 to June, 1942). The temperature and rainfall records for the period are shown in section 15 dealing with climate influencing rearing.

Seasonal variation in percentages of gum in silk filaments in Bengal.

Seasons of rearing and percentages of gum.

Race of worm.	July.	Aug.-Sept.	Oct.-Nov.	Dec-. Jan.	Feb.-March	April-May.	May-June, July.
Nismo	19·4	20	18·8	18·6	18·4	18·1	18·8
Nistid	19·7	19·2	18·8	18·4	18·2	18·4	19·6
Nistari	20	19	18·8	18·6	18·2	18·6	18·6
K. Nitchi (Japanese) ...	19·2	20	18·5	18·5	18·2	18·1	18·2
Itan. (A new hybrid under process of fixation) ...	19·8	19·2	18·8	18·2	18·1	18·2	18·8
Chotopolu	19·6	19·6	18·8	18·4	18·2	18·2	18·4

Cohesion :—The filaments are agglutinated together in the process of reeling to form the silk thread. This is a natural property but influenced very much by the method of reeling. Proper agglutination is brought about by the croisure given to the thread as it issues out of the reeling basin. The croisure should be sufficient to exert a concentric pressure bringing about proper agglutination and giving roundness to the shape of the thread and smoothness to its surface enabling the thread to stand the friction it is subjected to during the process of weaving. Cohesion is tested by subjecting the thread to friction in a cohesion testing machine and the number of strokes required to separate and open out the constituent filaments noted and the greater the number of strokes required the better the cohesion.

Hygroscopic nature :—Raw silk is hygroscopic in nature, absorbs moisture and increases in weight in a moist atmosphere and similarly gives off moisture and decreases in weight in a dry atmosphere. Therefore the weight of a lot changes with the moisture content of the air in the place where it is kept. In order that neither the buyer nor the seller may incur loss on this account transactions in raw silk are effected on 'conditioned weight" also called "correct weight". This means that all moisture is eliminated to find out the absolute dry weight and conditioned weight is obtained by adding 11 per cent of the absolute dry weight, allowable for moisture, to the absolute dry weight. In acutal practice samples are taken from the lot of silk under negotiation and

conditioning is done with the help of conditioning ovens (Fig. 79) and conditioned weight of the lot worked out. Modern conditioning ovens are electrically heated. Moisture absorbed by raw silk depends on the humidity of the atmosphere and fluctuates with it.

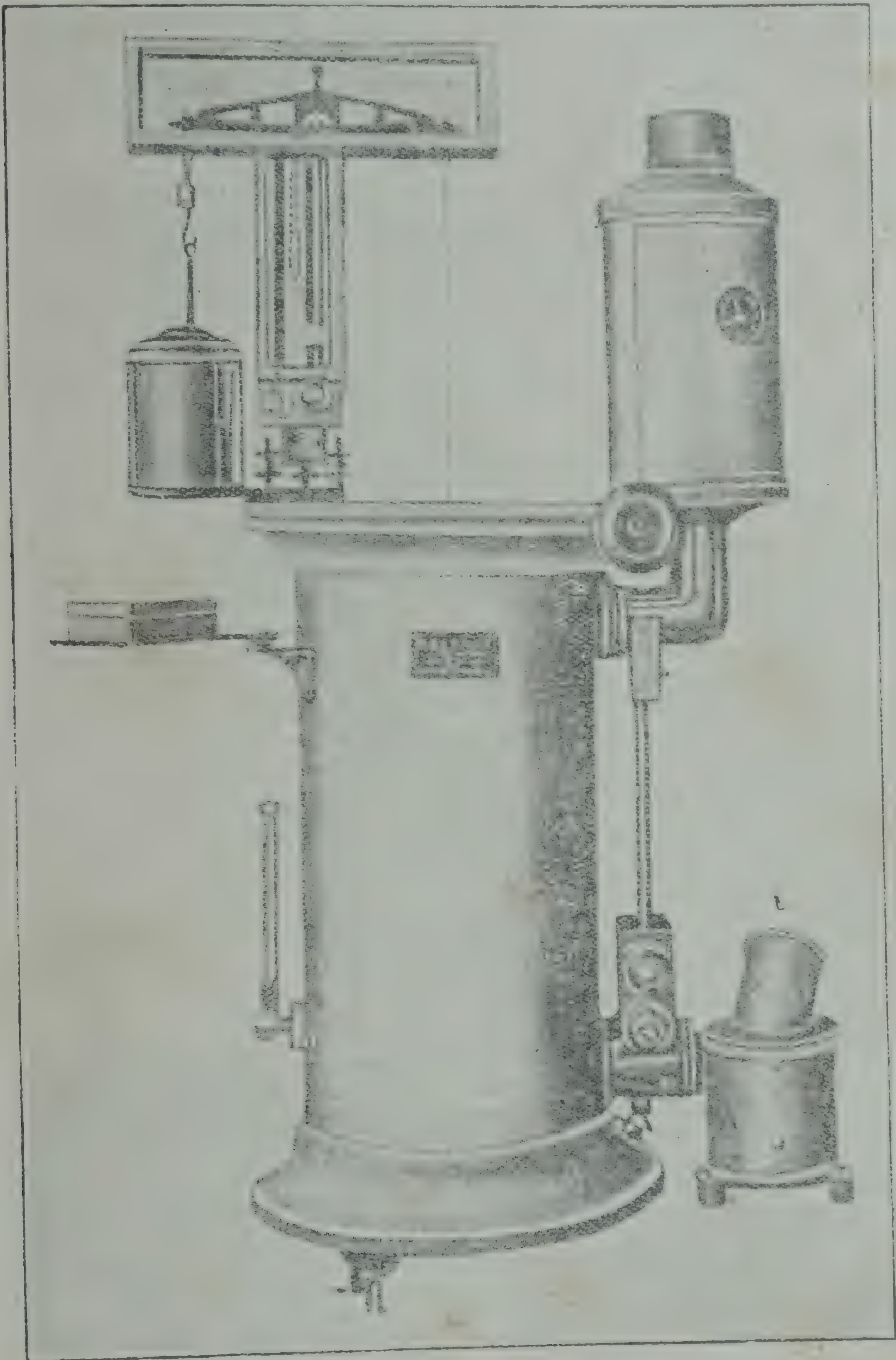


FIG. 79—Raw Silk Conditioning Oven.

Temperature has also an effect on the rate of absorption. The results of observations in the Bengal Government Rawsilk Conditioning House at Calcutta at about 83°F. temperature extending over about six months have been worked out by B. B. Roy as follows (Papers presented at the First All-India Sericultural Conference, p. 142).

Temperature	Humidity %	Moisture % in Raw silk
83±2°F.	66·0	11·01
	74·0	12·18
	77·5	12·50
	81·0	12·90
	82·0	13·30
	84·0	13·70
	87·0	14·30
	92·0	14·70

An idea of how a particular lot of raw silk will vary in weight with humidity will be obtained from these figures.

Japan was the first to have a Government Conditioning House at Yokohama through which all raw silk for export outside had to pass under the law with a certificate of conditioned weight. At present Japan has two Conditioning Houses at Yokohama and Kobe for export of rawsilk and several houses in the important districts where the weaving industry consumes large quantities of raw silk. Conditioning Houses are required now-a-days also to carry out test for determining quality and grade of the raw silk (described below) and give a certificate for all raw silk exported. All countries importing raw silk insist on these certificates from Government Conditioning Houses of the country of origin as these certificates indicate the quality and kind of raw silk they are importing and the actual weight they are getting. It is therefore incumbent on the Conditioning Houses to maintain their reputation for the certificates they issue. In India the first and only Conditioning House was started at Calcutta by the Bengal Government in 1938.

***Tensile strength* (*tenacity*) *and elongation* (*ductility*)** :—Tensile strength also called tenacity is indicated by the weight the thread can support before breakage. Silk thread stretches up to a certain point called the elastic or yield point from which it returns to its original length. But if stretched further it loses its elasticity and becomes permanently elongated and after certain elongation breaks. Strength or tenacity is indicated by the breaking load the thread can support before breakage and it is expressed in terms of grammes per denier. Elongation or ductility is indicated by the percentage of stretch before breakage. Tenacity and elongation are tested on the serigraph (Fig. 80) which has now replaced the serimeter which was used to test a single thread. On the serigraph a number of threads are tested together viz. 400 in the case of threads up to 13 denier, 300 for 13 up to 20 denier, 200 for 21-28 denier and 100 for 29 denier and above. In actual practice the 450 meter sizing skein (400 threads) may be used for deniers up to 20 and the 225 meter sizing skein (200 threads) for higher denier (*A Raw Silk Classification*, p. 34). The machine indicates the breaking load on a dial and at the same time records a graph on a chart. This graph is a straight line up to the yield point which marks elasticity and then bends upwards and continues bending up to the point of breakage which marks elongation and then rises vertically upwards.

Both tenacity and elongation are observed to vary with the moisture content which under Bengal conditions may be about 10 to 20 per cent of the absolute dry weight of the thread. An idea of this variation will be obtained from the following results of tests in the Bengal Government Rawsilk Conditioning House (Papers presented at First All-India Sericultural Conference, p. 140) for 13 denier raw silk 400 threads on serigraph (conditioned size).

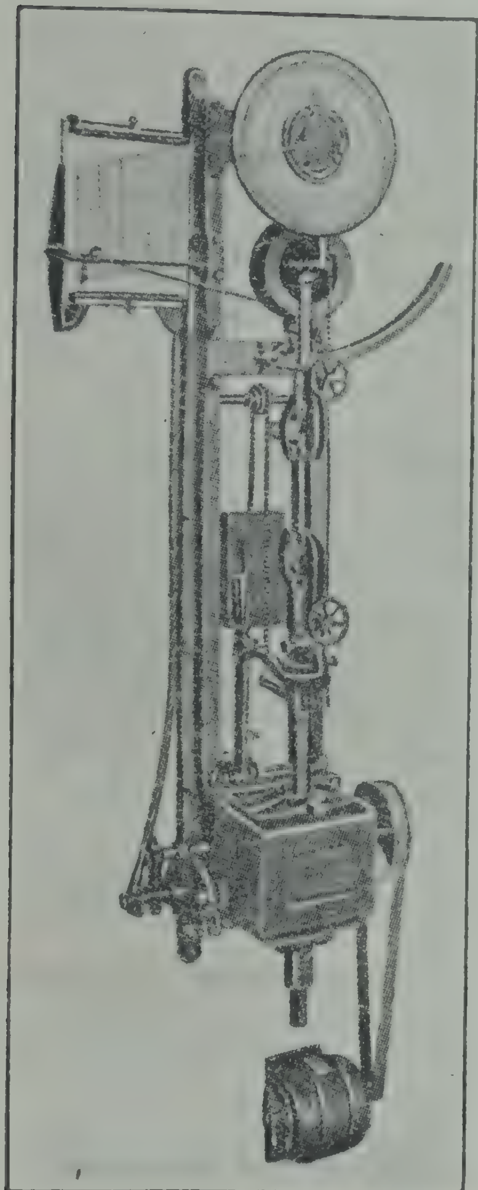


FIG. 80—Serigraph.

Moisture content %	Breaking load in kgs.	Tenacity in grammes per denier.	Elongation %
15·60	15·39	2·96	27
13·40	16·74	3·22	25
11·70	17·16	3·30	24
11·00	17·68	3·40	23
10·25	18·98	3·65	18

Tensile strength of raw silk decreases and elongation increases with increase in moisture content. Therefore tensile strength is taken as the breaking load per denier at standard humidity 65% and temperature 70°F. (as set by U.S.A. Bureau of Standards) or more correctly under conditions which bring about 11 per cent regain of the raw silk on its absolute dry weight. If 65 % humidity is maintained a temperature ranging from 70 to 80°F. practically makes hardly any difference (*Handbook of Industrial Fabrics* by G. P. Haven, 2nd Ed., p. 298). The same may be taken to hold good for silk. Tensile strength and elongation are required to be tested in an air-conditioned room with the standard humidity and temperature. In the absence of an air-conditioned room the American Society for Testing Materials has worked out for cotton a formula for correction of machine breaking strength to standard breaking strength, (loc. cit., pp. 319-24).

B. B. Roy has adapted it to raw silk as follows :—(Papers presented at the First All-India Sericultural Conference, p. 140).

S= Standard breaking strength wanted.

B=Breaking load indicated by serigraph.

M=Moisture content percentage.

r= Rate of decrease of strength with moisture percentage i.e. minus 2·63 per cent of the load at standard condition for each per cent increase of moisture as observed in the Conditioning House at Calcutta.

R=Moisture per cent at standard regain on net weight i.e. 9·9 per cent nearly.

$$S=\frac{100\ B}{100-r\ (R-M).}$$

To take an example:

When B (Machine reading of breaking strength)=15 kgms.

M=(Moisture) 16 per cent.

$$S\ (\text{standard breaking strength})=\frac{100\times15}{100-[-2\cdot63(9\cdot9-16)]}=18\ \text{kgms. nearly.}$$

Colour and lustre :—These in the raw silk are due to the sericin the colour of which is a race characteristic. Cocoons spun by different races of worms are golden yellow, yellow showing other shades, white, and white with greenish tinge. Raw silk reeled from the cocoons shows the same colouration but with various shades viz. yellow, reddish, brownish, cream, white, greenish or greyish. On degumming however the colour is lost and the degummed yellow silk shows the creamy white silky colour often with a slight yellow tinge. Raw silk from milky white cocoons does not show any tinge and that from greenish white cocoons retains a greenish tinge. Lustre may be affected by the reeling practice followed. Colour and lustre are judged by the eye in a steady north light.

Nature is taken to indicate hardness or softness and also roughness or smoothness, properties which are judged by touch, pressure and feel with fingers. *Hand*, the property of filling when a silken stuff is taken and held between hands, is really due to elasticity and is generally included in *nature.*

77. Quality of raw silk and how it is tested.

Silk is valued for the light, durable, lustrous fabrics and other articles of wear which can be prepared with it. Its tensile strength makes it peculiarly suitable for parachute manufacture. For manufacturing high class goods of faultless uniform texture a uniform faultless thread is necessary. The raw silk thread being made up of several cocoon filaments joined together in the process of reeling which is a handicraft and not machine operation, uniformity of thickness and faultlessness which contribute to superiority in the manufactured goods are dependent not on the natural superiority of the filaments of the cocoons but mainly on the efficiency of the reeling process. Continuity and uniformity of the thread in the hank and its freedom from faults and defects which impede processing and weaving are necessary. For how this can be ensured see section 70. Each and every lot of raw silk is, therefore, required to be tested for quality. Machinery and methods of testing quality have been developed and are in use. Buying and selling of raw silk is now-a-days done on the basis of the result of this test.

Standardisation of bales :—The bulk produce of no filature even with the highest reputation is accepted without test and for carrying out tests a particular weight of raw silk is required to be packed together in a bale. The present internationally accepted bale weights are for Europeans, Japans and Chinas—133 lbs. net, for Cantons —108 lbs. net. The weight of a Picul of China is also 133 lbs. net. As the first named three silks constitute the major portion of the world's raw sillk trade 133 lbs. is the common weight of a bale of raw silk in vogue now. Five per cent variation on this weight is allowed either way.

The American mills which are the biggest consumers of raw silk require the hank to be 58 to 59 inches in circumference and each hank to weigh $2\frac{1}{4}$ to $2\frac{1}{2}$ oz. ($5\frac{3}{4}$ to $6\frac{1}{4}$ tolas) in the case of fine sizes up to 12 denier, $2\frac{1}{2}$ to 3 oz. ($6\frac{1}{4}$ to $7\frac{1}{2}$ tolas) for 13/15 denier and 3 to $3\frac{1}{2}$ oz.($7\frac{1}{2}$ to $8\frac{3}{4}$ tolas) for deniers above 15. Japan has adopted the hank weight to be about 2·4 oz. (about $6\frac{1}{4}$ tolas) for 13/15 denier silk, packs 30 hanks in a book and 30 books in a bale, which theoretically should thus weigh 135 lbs. but actually weighs about 132 to 135 lbs. This practically satisfies the American demand for fine sizes up to about 15 denier.

As the tola is understood everywhere in India the standard weight of hanks may be 6 tolas for deniers up to 15 and $7\frac{1}{2}$ tolas for higher deniers. Books and bales may be made up as follows :—

Denier.	Weight of hanks in tolas.	No. of hanks in book.	Weight of book.	No. of books in a bale.	Weight of bale in lbs.
Up to 15	6	30	$4\frac{1}{2}$ lbs.	30	135
Above 15	$7\frac{1}{2}$	30	$5\frac{3}{4}$ lbs.	24	135

The ordinary exportable quantity is ten bales but may be one to ten bales which is described as a lot. The entire quantity of the raw silk in the lot is required to be uniform in quality. The tests carried out for determining quality are described below.

78. Tests for quality.

The tests are :—(i) *Visual and Tactual* for all the books and hanks in the lot with the help of the eye and fingers of the tester or inspector.

(ii) *Mechanical* with the help of the special testing machines. For this purpose samples are drawn from the lot.

The mechanical tests consist of the following.

A. ***Winding test***, on winding machine to determine the number of breaks which occur in winding the hanks on bobbins. Winding forms the first operation in the processing for manufacture. If hanks break often in the winding process the work is delayed and processing becomes troublesome and expensive. In the manufacturers' language if the winding of the hanks on one hundred swifts (tavelles) can be looked after by one operator it is known as " hundred tavelle " silk, that is of the best winding quality. According to the increase in frequency of breakages which require to be knotted the number of hanks under winding which can be looked after becomes less and less. This quality is at present indicated by determining the number of breakages which occur by actually winding 50 hanks of thread drawn at random from the lot on a winding machine for one hour and ten minutes, breakages occurring in the last one hour being taken for calculation. Apparatus and equipment required for winding test are:

Winding Machine :—(Fig. 81) capable of being adjusted to a speed of 110 metres (120 yards.), 140 metres (150 yards) or 165 metres (180 yards) per minute for average denier below 13, 13 to 17 and above 17 respectively.

Swifts :—Under Japanese regulations these are required to be automatic self-centering pinhub swifts weighing about 530 grams.

Bobbins :—The dimensions recommended in Japan and America are somewhat different as shown below. The bobbins are required to be smooth and well balanced so as to give a uniform tension and speed.

	Japan.	America.
Diameter of head	60 mm.	57 mm. ($2\frac{1}{4}$ in.)
Diameter of barrel	38 mm.	44 mm. ($1\frac{3}{4}$ in.)
Length between heads	85 mm.	75 mm. (3 in.)
Weight	105 grams.	Not specified.
Fillet between head and barrel ...	...	3 mm. ($\frac{1}{8}$ in.) radius.

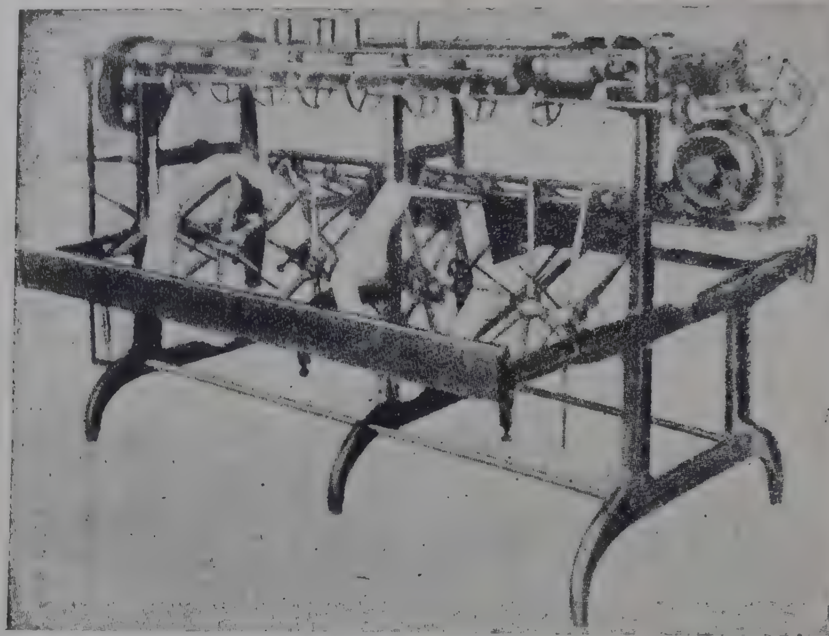


FIG. 81—Winding machine.

B. ***Tests for uniformity of size*** i.e. thickness of the thread in the whole lot. This quality is of the first importance in a lot of raw silk. Formerly it was tested by the sizing method only i.e. taking 450 metre lengths of the thread with the help of the deniering machine (Fig. 82) and determining the deniers of these 450 metre skeins with the help of the quadrant scale (Fig. 83). This sizing method has now been elaborated and by calculation, average size of the silk in the lot, deviations from the average size and maximum deviation have to be found out from a sufficiently large number of deniering skeins and considered for determining quality. In addition a new evenness test has been developed and adopted with the help of the seriplane machine (Fig. 85).

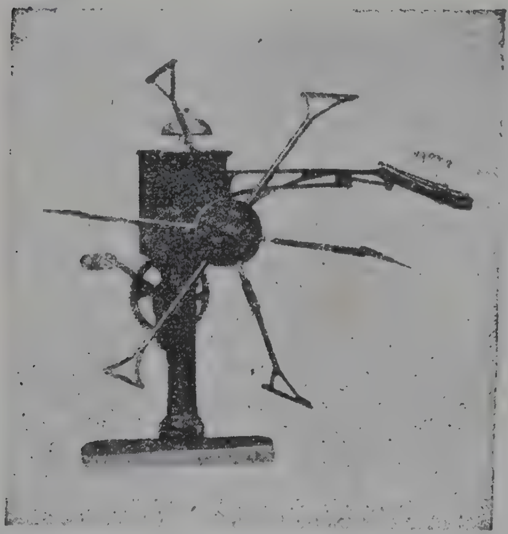


FIG. 82—Deniering machine.

FIG. 83—Quadrant scale.

The seriplane method enables differences in thickness i.e. unevennesses of different parts of the thread as well as minute faults to be perceived by the eye and also large faults such as presence of slugs, dirts and other uncleannesses which are responsible for defects in the finished products to be seen and counted. The seriplane winds and arranges the thread neatly side by side in regular order on a black board in panels five inches wide and when these panels are examined with the help of reflected lights unevenness and cleanness and neatness defects can be easily seen or counted. The tests carried out by these operations are:

I. By calculation after weighment:

(1) Average size.
(2) Size deviation.
(3) Maximum deviation.

II. By visual inspection on seriplane boards and counting defects which are present.

(4) Evenness.

(5) Cleanness.

(6) Neatness.

Defects are taken into consideration in the estimation of these qualities and these defects are detected, identified and their value determined with the help of apparatus and equipment described below.

For tests under I the apparatus and equipment required are :—

Sizing reel (Fig. 84) :—This is a machine to make 450 metre measured sizing skeins at a time, has a reel having a circumference of 1·215 metres (400 revolutions equal 450 metres) and revolving at a uniform speed of 300 revolutions per minute, is provided with a dial to show the number of revolutions of the reel and is equipped with an automatic stop-motion to stop the reel instantaneously when a thread breaks or when the skein is complete.

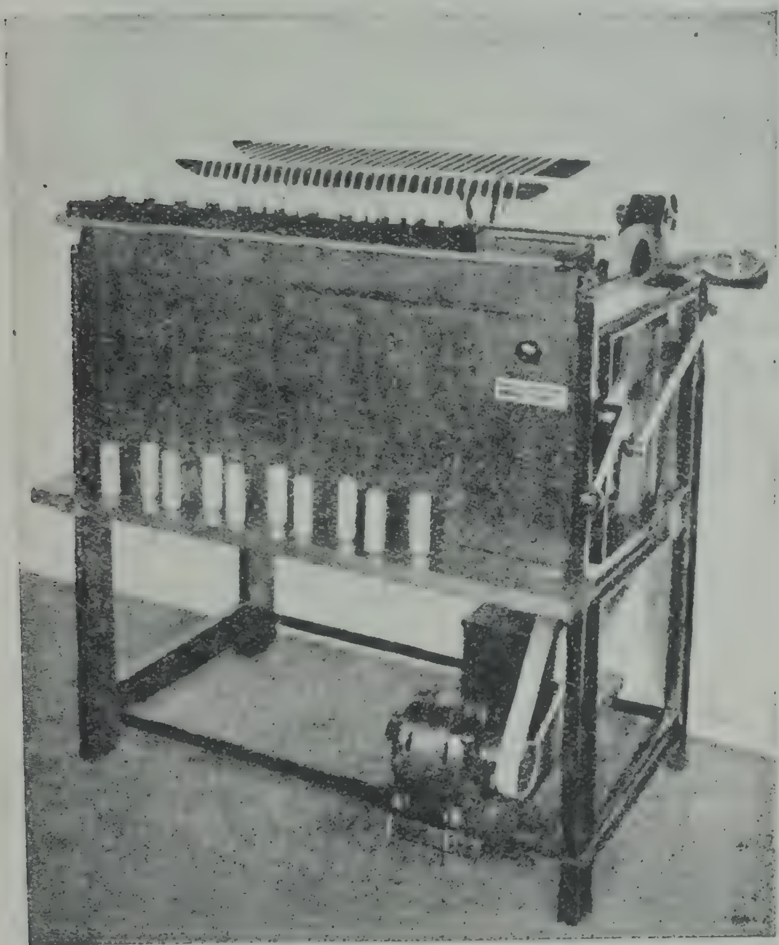


Fig. 84—Sizing reel.

Balance :—A chemical balance to determine the total weight of the sizing skeins with a sensitivity of 5 milligrams.

A *Quadrant scale* graduated in half deniers.

Conditioning oven :—(Fig. 79) for determining the conditioned weight of the test skeins.

For test under II the apparatus and equipment required are :—

Seriplane :—It is a machine designed to revolve an inspection board at a uniform rate of speed and equipped with a direct driven traverse, actuated by a fine feed screw capable of being adjusted to the size of the raw silk being tested and by means of which uniform spacing of the thread can be secured and also with a device to maintain uniform tension on the thread being wound and a counter to indicate the number of turns of

the thread on the board. The Cheney seriplane (Fig. 85) made by Cheney Bros. meets this requirement.

Inspection board :—It is a flat board upon which the thread can be wound on the seriplane and which has a uniformly flat black surface without any streaks, marks, bars or other faults likely to mislead the observer or give a false effect.

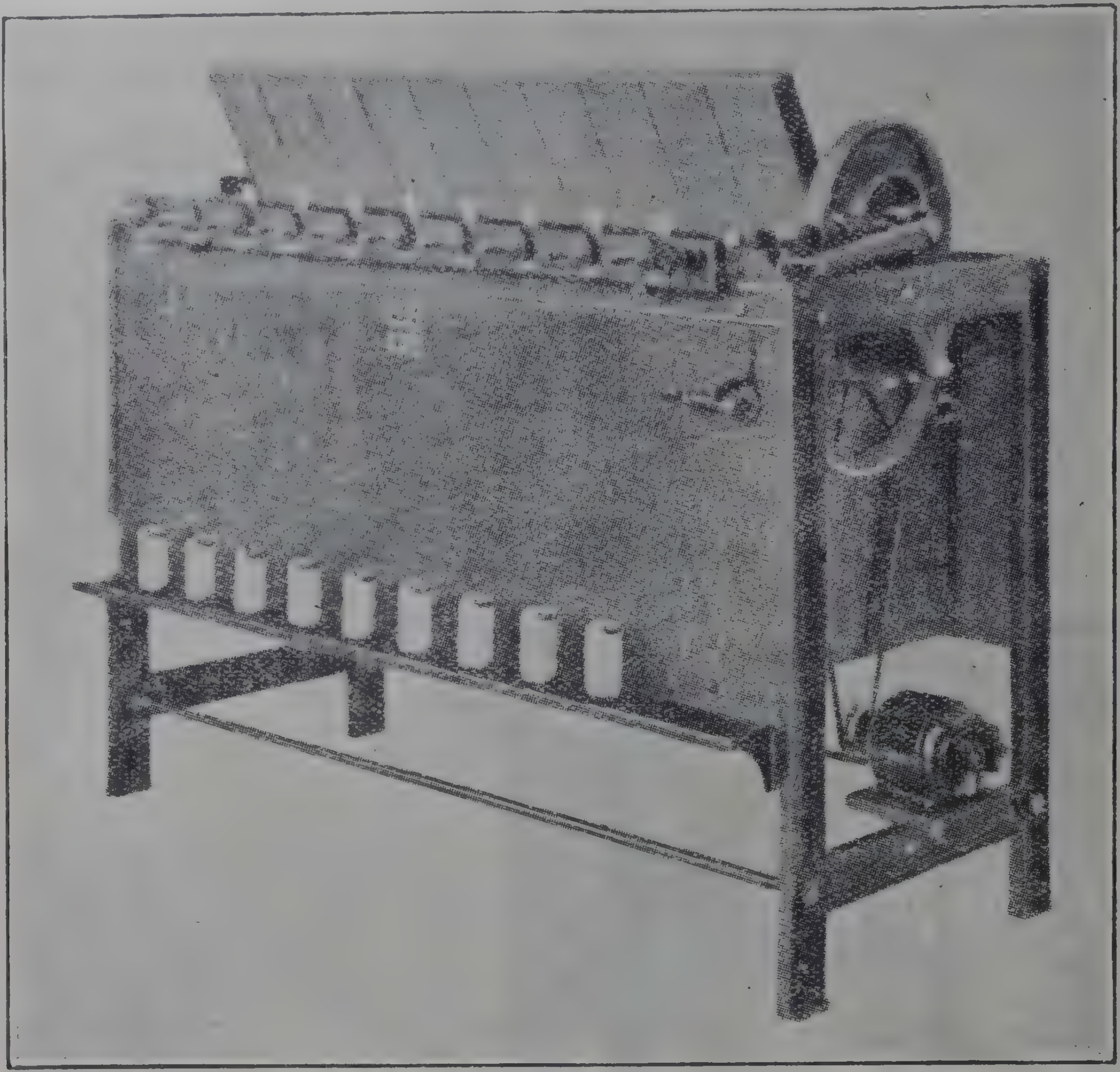


FIG. 85—Seriplane.

Standard photographs :—(Fig. 86). A set of official standard evenness photographs adopted by the Silk Association of America Inc., indicating relative values of evenness expressed in percentages.

In Japan Standard Evenness Photographs prepared by the Silk Conditioning House, Yokohama, are required to be used at present. For determining the intensity of variation of sizes Japan also uses four standard variation photographs prepared by the Conditioning House. Standard photographs illustrating cleanness and neatness defects are required to be used for identification of cleannes and neatness defects. Such photographs have been prepared both in America and Japan.

Inspection room :—The evenness estimation must be made in a standard Seriplane Inspection Room, the plan of which in the case of a single unit is shown in Fig. 87 and equipped with artificial lighting equipment described below.

Inspection rack :—A suitable rack on which the boards under inspection can be supported along with the Standard Evenness Photographs (Fig. 88).

Lighting equipment :—The lighting equipment shall consist of two vertical reflectors for evenness estimation with chromium reflecting surfaces, corrugated and shaped

so as to produce a diffused light of uniform distribution. Each reflector shall be 5′-5″ long and fitted with six 50 watt lamps. The reflectors shall be set as indicated in Fig. 87 and their lower edges shall be one foot above the floor.

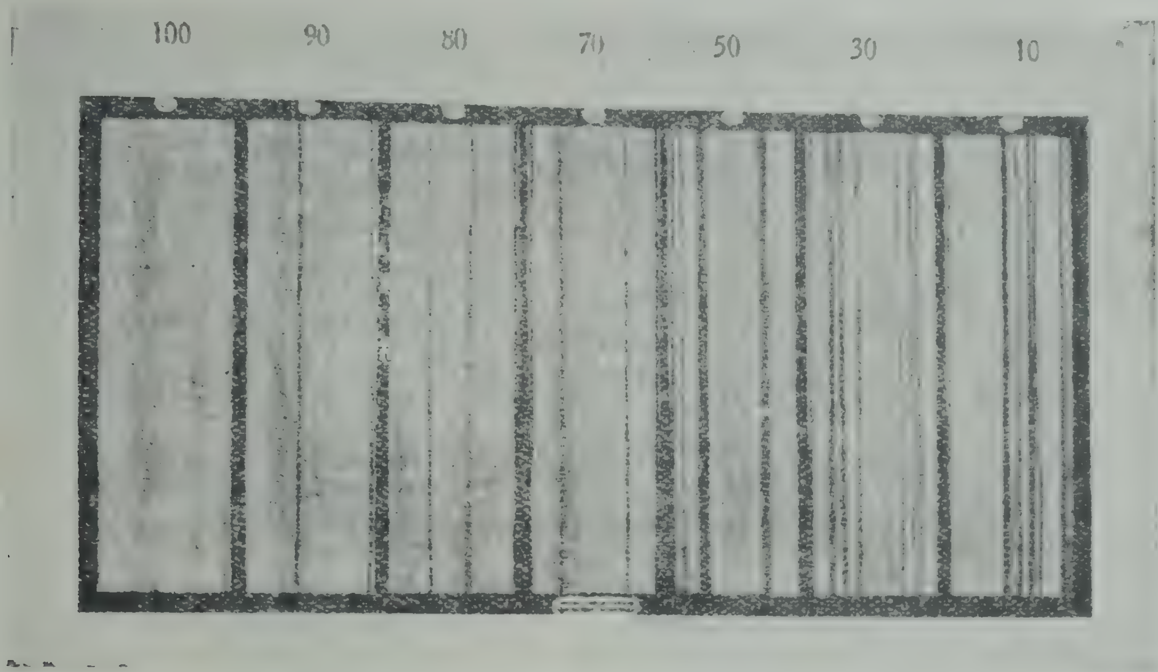


FIG. 86—Evenness Standard Photograph.

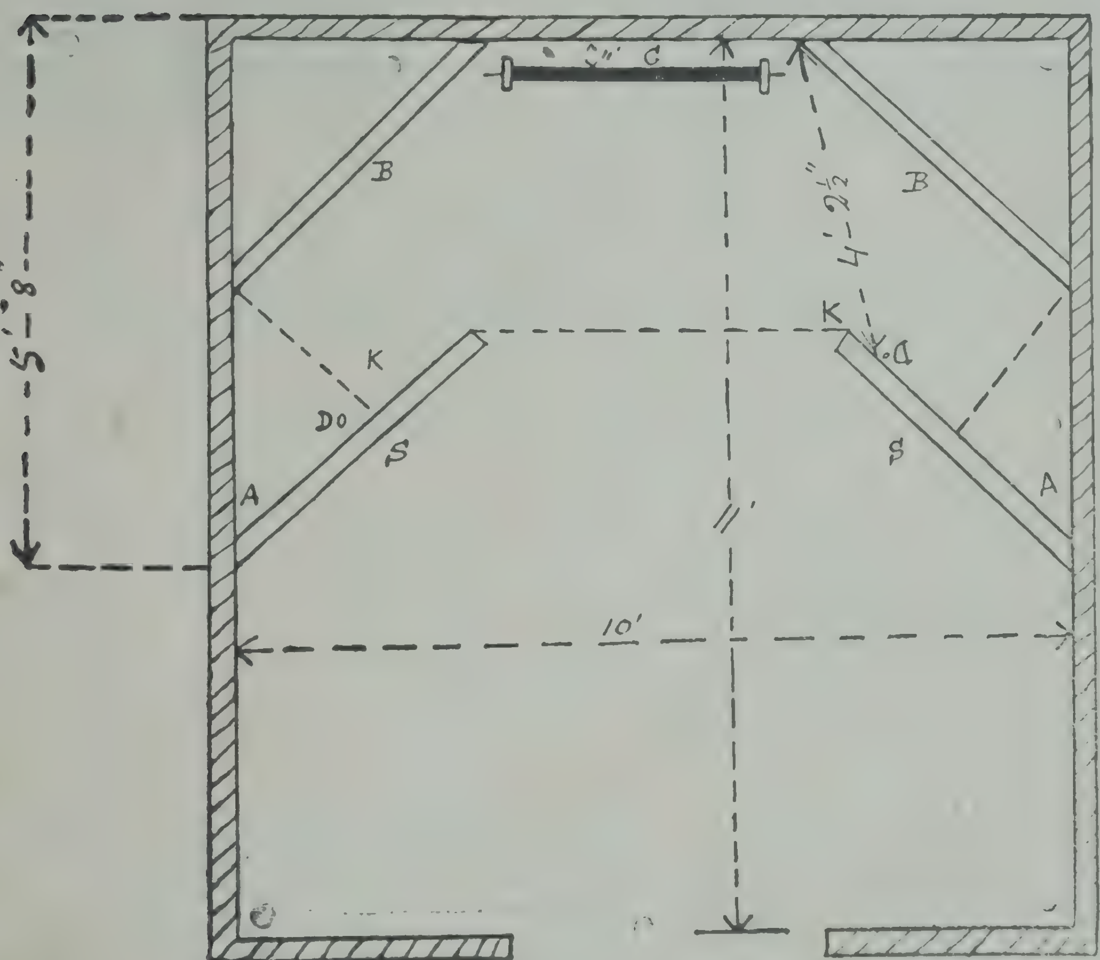


Fig. 87—Plan of Seriplane Board Inspection Room. External surfaces of reflecting screens S, walls B,C. and floor inside dotted lines are painted flat gray. The rest of the floor and walls, ceiling and internal surfaces of screens are flat white.

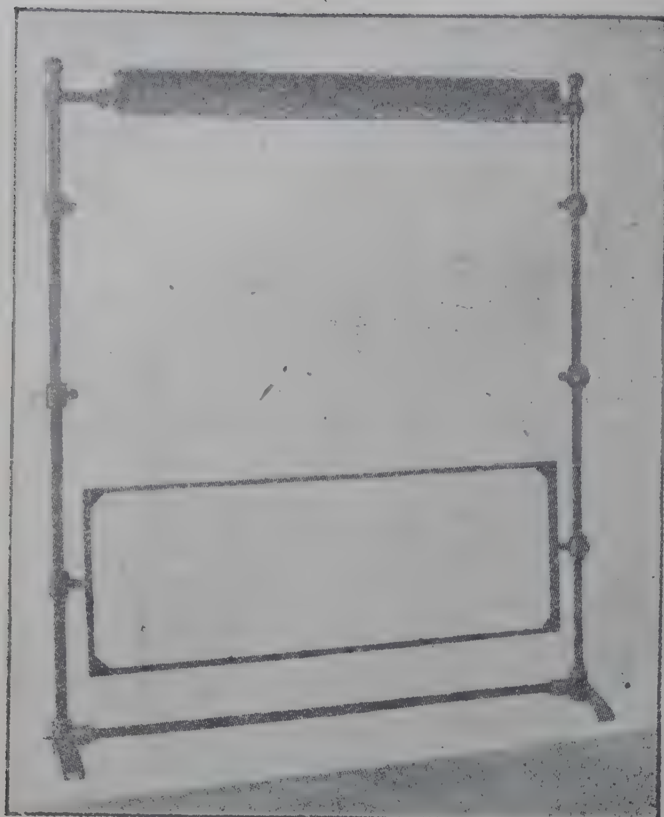


Fig. 88—Seriplane board inspection rack. Rack on which inspection boards are requird to be placed. The Evenness standard and two inspection boards are accommodated at the same time.

A horizontal reflector with either a corrugated chromium surface or a plain reflecting surface, four feet in length and with four sockets for four lamps, the end sockets with 60 watt and middle sockets with 50 watt lamps, shall be attached to the top of the inspection rack for cleanness and neatness estimations. A two way switch allowing of turning on and off of the vertical reflectors and horizontal reflector independently of each other is required. The lamps are required to be white and completely frosted on the inside.

Prepared panels :—A panel is a section of raw silk five inches wide and twenty inches long uniformly wound on the seriplane from a bobbin on an inspection board. Bobbins shall be wound from sample hanks for at least one hour and shall be upright in position for preparing the panel. The inspection board shall revolve at a uniform rate of 100 revolutions per minute but in case of excessive breaks the speed can be reduced to 80 revolutions per minute.

5''+20

The thread shall be spaced on the inspection panel according to size as follows :—

Average 10 to average 13 deniers	...	133	threads	per inch.
Average 14 to average 16 deniers	...	100	,,	,,
Average 17 to average 22 deniers	...	80	,,	,,
Average 23 to average 35 deniers	...	66	,,	,,
Average 36 to average 51 deniers	...	57	,,	,,
Average 52 to average 80 deniers	...	50	,,	,,

Defects :—Defects which are taken into consideration are the following :—

Evenness defects :—These are the portions of raw silk threads on the inspection board which show stripes caused by the variations in thickness of the thread to such an extent as to be easily noticeable by the eye. The degree of variation is called the intensity of variation which is indicated by assigning marks. The standard photograph has panels indicating 100, 90, 80, 70, 50, 30 and 10 percentages of defect. Estimate in the panels under test has to be made to the nearest 5 per cent from 100 per cent to 50 per cent and to the nearest 10 per cent below 50 per cent.

Cleanness defects :—These are of the following kinds and divided into (A) major and (B) minor defects (Fig. 89).

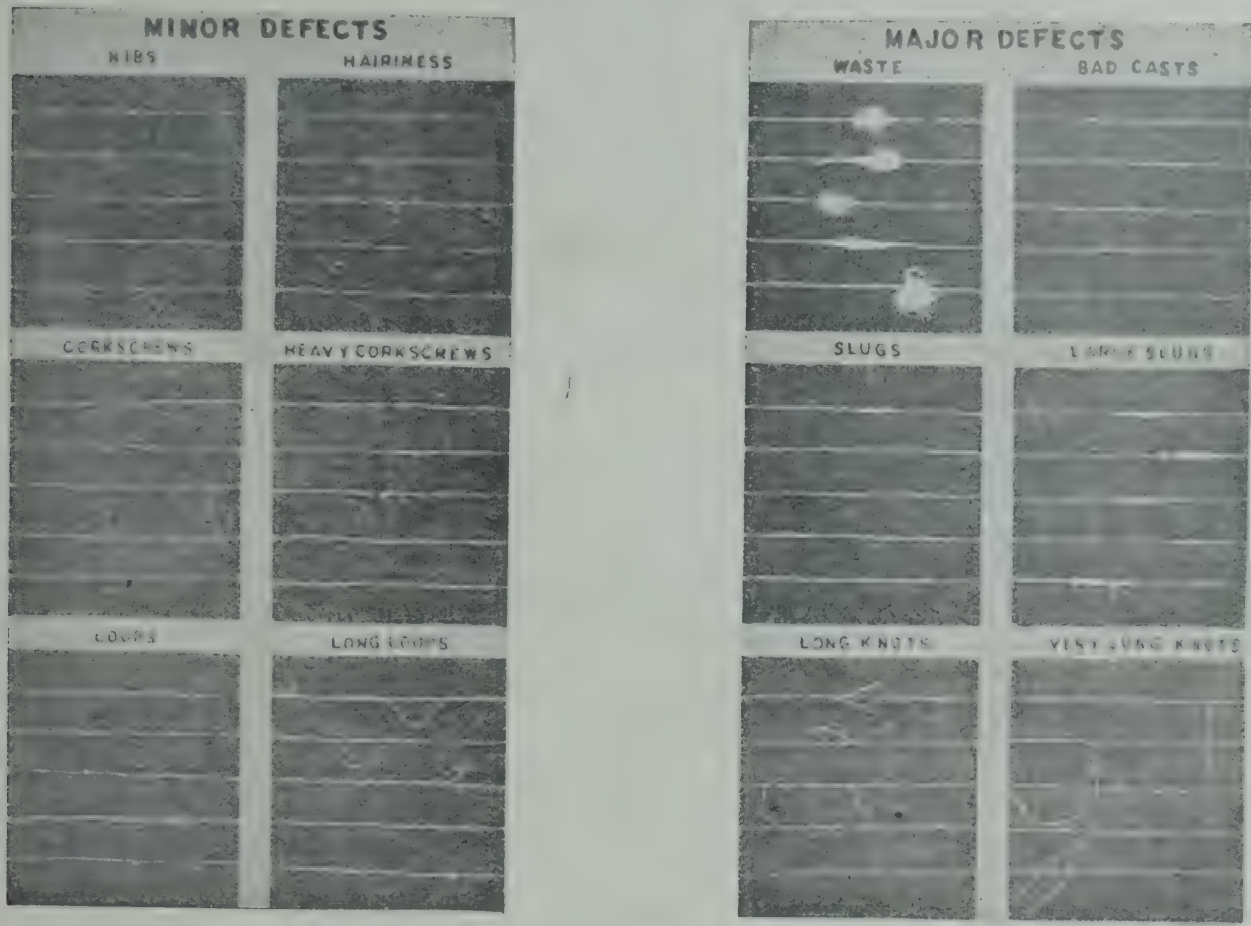


FIG. 89—Cleanness defects standards.

(A) *Major defects.*

Waste is a mass of tangled cocoon filament or fibre attached to the raw silk thread.

Large slug is an abruptly thickened place in the thread more than 7 mm. (¼″) in length.

Bad cast is an abruptly thickened place in the thread of any length due to the cocoon filaments not being properly fed to the thread or by feeding more than one cocoon filament at a time during reeling.

Very long knot is a knot having loose ends more than 17 mm. (⅝″) long.

Heavy corkscrew is a place in which one or more of the cocoon filaments are longer than the others; giving the thread the appearance of a very large spiral form.

Under the Japanese method of testing now adopted another item *Super Major Defects* is added to denote defects which are ten or more times as large as the minimum size of major defects in length or size.

(B) *Minor defects.*

Small slug is a thickened place from 2 mm. to 7 mm. (1/16″ to ¼″ long).

Long knot is a knot having loose ends from 3 mm. to 17 mm. (⅛″ to ⅝″) long.

Corkscrew is a place in which one or more cocoon filaments are longer than the others and give the appearance of a spiral form.

Long loops or loose ends (split ends) are loops or ends exceeding 20 mm. (¾″) in length when measured along the thread or exceeding 10 mm. (⅜″) in length when measured perpendicularly to the thread.

Neatness defects are defects smaller than minor cleanness defects and are shown on Neatness Standard.

Nibs are thickened places in the thread less than 2 mm. (1/16″) long.

Loops are small open places in the thread due to excessive length of one or more of the filaments.

Hairiness is the condition of the raw silk thread when there are numerous loose ends of cocoon filaments projecting from the thread.

Raw knots are knots having loose ends less than 3 mm. ($\frac{1}{8}$″) long.

Fuzziness is the condition of the raw silk thread when there are numerous fine loose particles of downing or fluffy substance attached to the thread.

Under the Japanese method of testing now adopted, another item *fine corkscrew* is added.

C. *Tenacity and elongation tests*.

Tenacity is the strength of a single thread expressed in grammes per denier.

Elongation formerly called elasticity is the amount that the thread is stretched when pulled to the breaking point.

Apparatus and equipment :—Serigraph (Fig. 80) which is a tensile strength testing machine with an autograph attachment recording simultaneously the pulling force and corresponding elongation of the thread.

The machine is required to be in a room having standard conditions of humidity (65 per cent) and temperature (70°F.).

Sample :—Ten samples are taken from ten sample hanks selected at random from a lot and kept under standard conditions of humidity and temperature for about one to two hours. The samples are then weighed to the nearest one-quarter denier and then tested.

The length of the tested portion is required to be 10 centimeters (4 inches) between the clamps of the machine when the test begins, and the speed of pulling at a uniform rate of 15 centimeters (6 inches) per minute. The following approximate number of threads for different sizes is recommended.

Up to average 13 deniers ...	...	...	400 threads.
Up to average 14 to 20 deniers	...	...	300 ,,
Up to average 21 to 28 deniers	...	...	200 ,,
Up to average 29 and above	...	...	100 ,,

Formerly tenacity and elongation (then called elasticity) used to be tested on serimeter. It has been found by experiment that the breaking force in grammes of a number of threads tested together on the serigraph is approximately seven-eighths of the sum of the breaking forces obtained by testing the same number of threads of the same silk singly on the serimeter.

D. *Cohesion test*.

The object is to determine the degree of agglutination of the filaments constituting the silk thread.

Apparatus and equipment :—The Duplan Cohesion Tester approved by the Silk Association of America and complying with the requirements of this test consists of a machine in which a continuous thread may be arranged between two sets of porcelain hooks in a zigzag fashion under a constant and uniform tension produced by a total load of 180 grammes (6·35 oz.) and in such a manner that the thread can be subjected to rubbing at twenty places simultaneously, the number of rubbing strokes being recorded automatically. The machine is required to be worked during the test in a room with standard humidity.

The sample for test shall consist of 20 test pieces for a lot or ten pieces for five bales from different skeins. The test pieces must be free from any cleanness defect or pronounced unevenness. After fixing the samples on the machine the motor is started slowly and the speed is not to exceed 140 revolutions per minute. After every ten revolutions the tension is slightly loosened and if any one of the pair of threads shows an opening one-quarter inch or wider the pair is taken to have been opened and the number of strokes recorded. The total number of strokes required to open all the threads divided by the number of threads gives the average test result.

79. Testing of a lot of raw silk and determination of its grade.

Lot :—The unit for testing of quality and grading is one lot consisting of one to ten bales. Lots consisting of more than ten bales shall be divided into ten bale lots and the remainder may be less than ten bales. Each ten bale lot or fraction thereof shall be sampled and tested independently.

Sample :—The sample for quality tests of a lot of raw silk now accepted in Japan and also recommended in America, consists of fifty original hanks drawn at random, an equal number from each bale, not more than one hank from a book (except in the case of single bale lot) and the hanks drawn from different parts of the books.

Variations in sampling :—If only winding test is to be carried out the American method allows only twenty-five hanks to be wound from outside. For full quality test 25 more hanks are required to be wound from inside. In Japan 20 hanks are wound from inside, 20 from outside, 5 hanks begun at about a quarter from outside and wound towards inside and 5 begun at about a quarter from inside and wound towards outside. Quality tests are carried out with the bobbins thus obtained.

In the test still officially recognised in America as set forth in "A Rawsilk Classification with Methods of Testing" (1929) the sample consists of (1) Ten original hanks drawn at random in the case of a bale. (2) Two such samples from every five bales of a lot of ten bales. (3) Four original hanks from each bale of a lot of 5 or 10 bales, the hanks thus numbering 20 or 40 respectively.

Grades :—The following grades are recognised beginning from the best in the order named viz. (1) special AAA, (2) AAA or 3A, (3) AA or 2A, (4) A, (5) B, (6) C, (7) D ,(8) E, (9) F and (10) G.

The last really indicates that any lot falling in it is below the category of recognised grades.

Items of tests for determination of grading :—As at present adopted in Japan they are:—

1. Visual inspections :—
   - (i) Lot inspection.
   - (ii) Skein inspection (not recommended in America).
2. Mechanical tests :—
   - (i) Winding test.
   - (ii) Size deviation test.
   - (iii) Maximum deviation test (a new item now adopted in Japan).
   - (iv) Average size test.
   - (v) Evenness test (a) average evenness of all panels,
(b) low evenness, being average of 25 per cent low panels.
   - (vi) Neatness test.
   - (vii) Cleanness test.
   - (viii) Tenacity and elongation tests.
   - (ix) Cohesion test (not yet officially adopted in America).

Major tests :—For purposes of grading the following are considered to be majo and the basis of grading is the composite percentage obtained by multiplying thei test values by the relative percentage of importance shown against each.

Average evenness	... ...	30 per cent.
Low evenness	... ...	30 per cent.
Neatness	... ...	20 per cent.
Cleanness	... ...	20 per cent.

Auxiliary tests :—The other items of test are considered to be auxiliary in grading.

Grading tables :—The test values of different items of test which determine the grade of a lot of raw silk as adopted in Japan at present are shown in the following table :—

Japanese Government Rawsilk Classification, 1938

CLASSIFICATION TABLE.

Items	Grades	AAA*	AAA	AA	A	B	C	D	E	F	G
Composite (%)	17d. and below	90	88	86	84	82	80	77	73	68	Below 6
	18d. and above	90	88	85	83	81	79	76	72	67	,, 67
Evenness (%)		92	89	86	84	82	80	77	72	67	,, 67
Low evenness (%)		83	80	77	74	72	69	65	60	54	,, 54
Neatness (%)		92	90	88	87	85	83	81	77	73	,, 73
Cleanness (%)	17d. and below	93	91	90	88	86	84	82	78	74	,, 74
	18d. and above	91	89	87	85	83	81	78	74	70	,, 70
Size deviation (denier)	15d. and below	0·90	1·00	1·10	1·20		1·30		1·40		Above 1·40
	16 to 18d.	1·10	1·20	1·30	1·40		1·50		1·60		,, 1·60
	19 to 22d.	1·25	1·35	1·45	1·55		1·70		1·90		,, 1·90
	23 to 27d.	1·50	1·60	1·70	1·80		2·00		2·20		,, 2·20
	28 denier and above	1·90	2·00	2·10	2·20		2·40		2·60		,, 2·60
Maximum deviation (denier)	15d. and below	4·0	4·1	4·3	4·6		5·0		5·5		,, 5·5
	16 to 18d.	4·5	4·8	5·2	5·7		6·3		7·0		,, 7·0
	19 to 22d.	5·0	5·4	6·0	6·8		7·8		9·0		,, 9·0
	23 to 27d.	6·0	6·5	7·2	8·2		9·5		11·0		,, 11·0
	28 denier and above	7·5	8·0	8·7	9·7		11·0		13·0		,, 13·0
Winding (Breaks)	17d. and below	25	30		40		50		70		,, 70
	18d. and above	20	25		30		40		55		,, 55
Tenacity (grammes)	17d. and below	3·4	3·3				3·2				Below 3·2
	18d. and above	3·5	3·4		3·3		3·2				,, 3·2

Items	Grades	AAA*	AAA	AA	A	B	C	D	E	F	G
Elongation (%)	17d. and below	19·0	18·0					17·0			Below 17·0
	18d. and above	20·0	19·0		18·0						,, 18·0
Cohesion	17d. and below	30									,, 30
(strokes)	18d. and above	50			45		40				,, 40

The rules for determining the grade of a lot are :—

1. The grade of a lot is first determined according to the value of the composite percentage of the major tests provided that the value of each of these tests conforms to that stated in the table for this grade and failing that the grade is lowered to that indicated by the lowest value of any one of them.

2. If the test values of size deviation, winding, tenacity, elongation or cohesion do not conform to what are shown in the table for the grade arrived at according to the rule 1, the lot is degraded as many grades as the maximum difference between this grade and the lowest grade to which any of these tests falls.

3. If the maximum deviation of the grade arrived at according to rules 1 and 2 is found to be lower the lot is degraded one grade further.

4. If uniformity is lacking in lot inspection and in general finish the grade arrived at according to the preceding three rules is degraded one step further.

5. If the number of breaks in the winding test is above 90 for deniers up to 17 and above 80 for higher deniers the lot is graded G.

The grading still officially in force in America is shown below :—

Japanese Rawsilk, white and yellow, any size.

10 Bale Lots.

Grades	AAA	AA	A	B	C	D	E	F	G
Major Tests—									
Evenness, average 160 panels % ...	90	87	85	83	81	78	73	68	Below 68
Evenness, average 40 low panels % ...	81	78	75	73	71	66	60	55	55
Cleanness %	92	90	90	90	85	80	80	75	75
Neatness % ...	90	85	85	85	85	80	75	75	75
Auxiliary Tests—Size deviation									
Average 9 to 15 denier less than ...	1·00		1·00	1·10	1·20	1·30	1·40	1·50	Above 1·50
Average 16 to 31 denier ...	1·50		1·50	1·50	2·00	2·00	2·00	2·00	2·00
Average size variation—									
Average 9 to 12 denier ...	·40 denier		·40 denier		·40 denier		·40 denier		·40 denier
Average 13 to 18 denier ...	·40 ,,		·50 ,,		·50 ,,		·50 ,,		·50 denier
Average 19 to 22 denier ...	·50 ,,		·50 ,,		·50 ,,		·75 ,,		·75 denier
Average 23 to 31 denier ...	·80 ,,		·80 ,,		·90 ,,		1·00 ,,		1·00 denier
Strength (serigraph) ... Grams per denier	3·5		3·50		3·3		3·0		Below 3·00
Elongation (serigraph) per cent	20·0		20·0		19·0		18·0		18·0
Winding-breaks per hour per 20 skeins ...	10		10		20		30		Above 30

A lot conforming to all the characteristics of any given grade in the major tests may test one grade lower in the auxiliary tests without degrading the lot, but if the auxiliary tests of the lot are two grades lower, the lot is rated one grade below that indicated by the major tests.

80. Testing and recording results.

Lot inspection :—Inspection is carried out of all the books of the lot. Books and hanks observed to be not uniform are to be rejected or replaced. The items of inspection are :—

(1) Uniformity as to colour, lustre and hand and recorded as excellent, good, fair or slightly inferior.

(2) General finish of the whole lot with reference to the following defects :—

(a) Re-reeling hard gum spots, gummed hanks, irregular traverse, double ends, etc.; gum spots are to be indicated as soft, hard or very hard.

(b) Finish :—Improper lacing ; dropped threads; pulled threads; imperfect traverse; loose ends ; double ends ; etc.

(c) Make up :—Irregular books and hanks ; improper twisting of hanks and making of books ; floating threads ; lacing of cord through books and hanks ; cut ends ; dissimilar hanks ; streaky threads ; sooty hanks ; foreign substance adhering to the hanks ; hanks and books of different nature ; etc.

(d) Damage, by friction or insects ; damaged hanks or books ; soiled thread ; discoloured thread ; books out of shape ; etc.

The record should show :—

(1) Uniformity
(2) General finish } Excellent, fair or slightly inferior.

(3) Colour (a) Shade—(1) white raw silk—white, greenish, cream, brownish or grayish.
(2) Yellow raw silk—yellow, reddish or darkish.
(b) Degree—light, medium, deep.

(4) Lustre—bright, medium or dull.

(5) Hand— (a) Nature—hard, oridnary, soft.
(b) Smoothness—smooth, ordinary or rough.

Hank inspection :—The samples are ten hanks taken from the remnants of the winding test.

The inspection is determining (1) super major defects by opening and examining the hanks on a black plate artificially lighted from above and (2) gum knots against artificial lighting coming from a cabinet through a white opal glass plate on which the hanks are spread.

Each large knot is penalised by 20 per cent, a medium one by 5 per cent and a small one by 1 per cent.

The records for (1) are to be :

A few— for 3 or 4 defects.
Several— for 5 to 9 defects.
Many— for 10 or more.

The records for (2) are to be :

A few—for total penalty of 20% to 49 %.
Several for total penalty of 50% or more.

Winding test :—As the speed of winding machine is to be set according to the denier of the raw silk unless the denier stated by the party for the lot can be depended upon it should be determined at the beginning of the test and the machine set properly.

The hanks to be tested are to be put on the swifts with care to ensure that each one is in good condition. If gum spots are present they should be softened by both hands holding firmly the hank in the flat condition at about an inch from the spot on either side and twisting it one-half turn while stretched taut and gently rubbing it until the gum spot becomes loose and open, care being taken that the thread is not damaged. The traverse should be properly set so as to have a compact bobbin.

Winding is to be continued for one hour and ten minutes.

The record should show :—

Number of hanks wound.

Breaks during first 10 minutes which are however not to be included in the test result.

Breaks during the next one hour which if the number of hanks under test be less than 50 should be calculated and recorded as so many per 50 hanks per hour.

If breaks occur in large numbers the present Japanese method requires the causes causing them to be noted such as hard gum spots, brittle, feeble, irregular traverse, disturbed traverse, fine ends or cut ends.

Size deviation test :—Four sizing skeins, each 450 meters, are taken from each of 50 bobbins obtained in the winding test i.e. 200 sizing skeins in all (total length 90,000 meters) on the sizing reel. They are weighed together on the balance and the average for one skein found out and recorded as the central size on the record sheet after being taken to the nearest half denier. Then each skein is weighed on the quadrant scale to the nearest half denier and the result noted on the sheet in its place. Size deviation is found out by adding together the differences of the deniers (taken up to the nearest half denier) of the skeins from the central size and dividing this sum by the total number of skeins i.e. 200 and recorded up to the second place of decimal. The record should also show the number of skeins falling under different deniers.

Maximum deviation test :—Maximum deviation is calculated from the size deviation test. The average of record made for the four coarsest sizes is worked out and also its difference from the central size. Similarly the average of the four finest sizes is worked out and its difference from the central size. The larger of these two differences is the maximum size deviation and recorded up to one place of decimal.

Average size test :—The 200 sizing skeins are placed in a conditioning oven and their conditioned weight is determined and average size calculated in deniers. The result is recorded in deniers up to the second place of decimal.

Evenness test :—Two panels are prepared on the seriplane inspection board on the seriplane from each of the 50 bobbins obtained in winding test i.e. a total of 100 panels. Estimation of the percentage value of each panel is conducted in the seriplane inspection room by the estimator standing at a distance of 2·1 meters directly in front of the inspection rack, under proper lighting and after comparison with the standard photographs. The record is to show the estimated percentage of each panel, the average evenness percentage of a total of one hundred panels and the low evenness percentage which is the average percentage of low panels representing one-fourth of the panels inspected.

Neatness test :—This test is carried out on the same panels as for evenness test by the estimator standing at a distance of 0·6 meters (2 ft.) in front of the inspection rack under the proper system of lighting. Each panel is carefully compared with the standard photographs for neatness defects and its nearest value estimated in percentage.

From 100% to 50% the estimate is to be to the nearest 5% and below 30% it is to the nearest 10%. The record is to show the estimated neatness percentage of each panel and the average of one hundred panels.

Cleanness test :—This test is carried out on the same panels as for evenness test and with lighting and position as in neatness test. The actual number of cleanness defects of each class and kind described in the accepted definitions and determined

after comparison with the standard photograph for cleanness defects are counted on the threads of both sides of the inspection board but not on the parts of threads lying on the edges of the boards. The record is to show the number and kind of the defects and the cleanness percentage determined by deducting from 100% the total penalty calculated by penalising defects at the following rates:—

For each super major defect	...	0·8%.
For each major defect	...	0·3%.
For each minor defect	...	0·08%.

Tenacity and elongation tests:—Ten samples are prepared, one from a bobbin out of the 50 bobbins obtained in winding test on the sizing reel according to the denier of the thread under test. The samples are required to be placed for a sufficiently long time in a place where standard humidity (65%) can be maintained in order to allow them to be adjusted to standard condition. Each sample is then required to be carefully weighed for sizing and then tested for tenacity and elongation on the serigraph in a room with standard humidity. The tenacity is expressed in grammes per denier and elongation in percentage of the total stretch of the portion tested. The average of the test results of the ten samples is taken up to the second place of decimal.

Cohesion test:—It is required to be carried out under standard conditions of humidity. Samples are taken from the bobbins obtained in winding test. The record is to show the average of 20 test pieces omitting decimal.

81. Certificate of testing.

The certificates for conditioned or correct weight and for quality can be on the same sheet or on separate sheets.

The certificate for the conditioned weight should show the details in the case of a lot.

GOVERNMENT OF BENGAL.

RAW SILK CONDITIONING HOUSE, CALCUTTA.

Certificate of Tests for Quality.

No.	Quality........................	
For Messrs	*Major tests*:—	
	Evenness (Sireplane)	Per cent
Mark	25% Low-panel	,,
Date	Cleanness	,,
Filature	Neatness (By inspection)	,,
	Composite percentage	,,
	Subsidiary tests:—	
Examination—(Words not applicable are scored out).	Average size	Denier
No. of books—	Size deviation	,,
	Maximum deviation	,,
Colour—White, yellow, light, medium, full.	Size range...... denier to....	denier
Lustre—Very good, good, fair.	Winding-breaks per hour per 5 hanks	
Feel—Smooth, rough.	Strength—..... grammes per denier	
Nature—Hard, medium, soft.	Elongation—......per cent.	
Gum—Much, slight.	Cohesion—......strokes.	
Lot uniformity—Very good, good, fair.	*Grade*—	

Officer-in-charge,
Raw Silk Conditioning House.

Conditioned weight.

Moisture	%	Net weight of samples drawn	lbs.
Shirt weight	lbs.	Total net weight	lbs.
Tare	lbs.	Total conditioned weight	lbs.
Net weight of raw silk in sealed.... bale	lbs.	Loss in testing (Net weight)	lbs.
		Remnants of samples	lbs.

Officer-in-charge,
Raw Silk Conditioning House.

The certificate for quality at present issued by Japan is a comprehensive one and is shown below.

THE JAPANESE GOVERNMENT.

SILK CONDITIONING HOUSE.

Certificate for Quality Test for Grading.

Test No.................White raw silk		10 Bale Lot Mark & Bale Nos................	
Grade......................................		Chop.....................	
Evenness..................................	Per cent	Average Size...........................	Denier.
Low Evenness..........................	,,	(Conditioned)	
Neatness	,,	Size deviation........................	,,
Cleanness................................	,,	Maximum deviation................	,,
Composite Percentage................	,,	Winding..................................	breaks
		Tenacity.........................grams per den.	
		Elongation...............................	Per cent
		Cohesion	strokes.

Evenness test.			Neatness test.		Cleanness test.		
Percentage	Number of Panels	No. of low panels	Percentage	No. of panels	Defects Super Major defects		Number
100			100			Waste........................	
95			95			Large slugs................	
90			90		Major Defects	Bad caste..................	
85			85			Very long knots..........	
80			80			Heavy corkscrews.......	
75			75			Total........................	
70			70				
65			65			Small slugs................	
60			60			Long knots................	
55			55		Minor Defects	Corkscrews................	
50			50			Long loops................	
40			40			Loose ends................	
30			30			Total........................	
20			20				
10			10			Total Penalties..........	
Average Percentage........................			Average Percentage..............................			Cleanness Percentage...	

	Visual Inspection							
Uniformity	General Finish	Colour		Lustre		Hand		
		Shade	Degree	Kind	Degree	Nature	Smoothness	

Director.

The actual records of winding and size deviation tests are also provided with the certificate.

82. The quality of raw silk at present produced in India.

Kashmir and Jammu :—The Sericultural Departments here have large filatures which are equipped with Italian machinery or with good machinery locally manufactured. Therefore there are all facilities here for production of good raw silk. The

chops of raw silk produced in Kashmir filatures are Lotus, Iris and Tulip and those of Jammu filatures are Neel, No. I and No. II.

The writer had occasion to test in the Bengal Conditioning House samples prepared by these Departments for the Tariff Board, some of which were as good as 3A. Then he had occasion to deal with large quantities of raw silk from the filatures of both these places for manufacture of parachute components viz. fabric for canopy, heavy and light cords, heavy and light sewing threads and tapes. The large supplies were invariably of such poor quality that they failed to attain any grade at all and came to be placed under G. The inherent quality of the raw silk was good and the defects in the quality were due to defective reeling. Some of the lots were so bad that they could not be worked in the power mill mainly on account of frequent breakages.

Mysore :—Practically the whole output of raw silk here was until lately reeled on hand-turned *charka* on basins heated with wood fuel. The different qualities of *charka* silk are marked as No. 1, No. 2, and No. 3 from the best downwards and all have defects of unevenness, uncleanness and numerous breakages. The Government maintained a small filature at Mysore with French type machinery. The Mysore Silk Filatures Ltd., started a filature with 200 basins in 1938 and more filatures have been recently started. The filature basins are worked with steam.

Madras :—In Kollegal the major portion of reeling is done on *charkas* as in Mysore. A filature has been working here for sometime. The writer had occasion to test samples produced here and found them good but the bulk supply not better than *charka* silk. As in other places this is due to defects in reeling methods.

Bengal :—As pointed out in section 72 in recent times the entire output of raw silk was till lately reeled on hand turned *charkas.* The majority of these *charkas* worked on basins heated with wood fuel and then known as *ghar-ghai* (home basin) or *katghai* (basin heated with wood or coal fuel). Some of the basins worked with steam from boilers.

The qualities of the raw silk produced are known under the general term *Khangru* or *Ghungru* or *Desouri* in the Punjab. Different kinds are known as *tana* i.e. raw silk fit to be used as warp thread and *bharna* i.e. raw silk for use as weft thread. The third quality known as *ghora*, a coarse, uneven and dirty silk, as pointed out in section 69, is the result of coarse reeling and is in demand for weaving coarse *lungi* in use in Chittagong, Burma and other places. *Tana* and *bharna* silks are in demand for weaving ordinary silk *saris*, *dhotis*, shirtings and suitings.

Bengal *tana* and *bharna* raw silks have been tested and analysed in the Conditioning House and Roy has published the results (Papers presented at the First All-India Sericultural Conference, 1939, pp. 95-98). Their serious defect is the large number of breakages in unwinding rendering them unfit for use in power weaving. In evenness, cleanness and neatness some samples are fairly good.

Tana silk is supposed to have a superior tensile strength, elasticity and cohesion. The test employed by weavers is breaking a thread, feeling the strength required in breaking and observing the broken ends. If the constituent filaments of the thread separate out at the broken ends the thread is considered unfit to be used for warp. Actually *tana* and *bharna* are reeled in about similar thickness but *tana* with greater care in cooking at a higher temperature and in cleanliness. *Tana* silk therefore is on the average superior in evenness, cleanness, strength and elongation. But there is no consistency of the differences and no recognised well-marked tests for these differences. It is more a matter of the experience and skill of the reeler able to reel *tana* silk and of the weaver to judge what can be used for *tana.* There is apparently some effect of the season of rearing of the cocoon on *tana* silk which is mainly reeled from cocoons reared in *Bhaduri* (September) crop in Malda District.

The method in vogue of indicating the size (i.e. denier in scientific method) of the *tana* thread is by the number of ends which can be used in the warp of a piece 44

inches wide. The sizes ordinarily used by the weavers and the deniers to which they correspond are as follows :—

Classification by reelers and weavers.			Denier.
2,600 *tana*	...	...	13–16
2,400 ,,	...	...	16–20
2,200 ,,	...	...	20–24
2,000 ,,	...	...	24–28
1,800 ,,	...	...	28–32

Tana and *bharna* silks fail to attain any grade mainly on account of numerous breakages and also other defects. But samples of re-reeled raw silk reeled on Ghosh and Roy type machines have come up to 2A grade. Bulk supplies, however, although not so bad as in the case of bulk supplies from Kashmir and Jammu, are of low grades F or E or fail to attain grade and fall in G. This is clearly due to defects in reeling methods.

83. Kinds of raw silk produced in different countries and their classification.

In order to be able to understand the kinds of raw silk i.e. kinds of thread obtained from silk cocoons and used in silk weaving and other manufactures the following points have to be remembered.

1. Cocoons obtained even from the same lot of worms contain a proportion which cannot produce good thread (see section 66).

In order to understand this point clearly actual products may be considered. The results of sorting about 81,000 lbs. of dry univoltine cocoons in Kashmir for being reeled in the filatures there are as follows (Silk Industry of Kashmir and Jammu, 1940. p. 19).

Proportions (per cent)	*Kinds.*	
71·7	Cocoons No. 1 i.e. the best quality	Reelable into fine raw silk.
1·7	,, No. 1 small size	
16·5	,, No. 2 second quality.	
3·6	,, Reelable *puda* (soiled)	Reelable into coarse raw silk.
·1	,, Melted (crushed) *puda*	
3·7	,, Dopost i.e., double	
1·4	Fluff removed from cocoons	Waste.
·7	Pierced or cut by rats	

Lotus brand (*chop*) i.e. extra quality raw silk is reeled from No. 1 cocoons in modern filatures with Italian machinery, Tulip brand i.e. No. 2 quality raw silk is reeled from No. 1 and No. 2 cocoons in old type locally manufactured wooden filatures.

Iris brand raw silk is reeled from No. 2 cocoons in modern filatures.

Coarse raw silk is reeled from other cocoons and of this coarse silk, too, there are several kinds according to evenness or freedom from dirts and impurities.

All classes of cocoons produce such different qualities of raw silk everywhere.

2. Cocoons vary in quality according to the races of worms. This question has been discussed in section 66. Different qualities of raw silk are obtained from different kinds of cocoons. Generally speaking :—

(a) The univoltine cocoons of Europe, Japan, China and Kashmir are capable of yielding the highest qualities of raw silk obtainable at present in the world.

(b) Next come cocoons of the type of hybrids like Nismo and Nistid of Bengal and first generation cross cocoons of Mysore and Madras.

(c) Last come multivoltine cocoons of the type of Nistari of Bengal and Mysore cocoons.

(d) Apart from the inherent qualities described under (a), (b) and (c) climatic adversities, diseases and starvation may interfere with the quality of all cocoons. There is no hard and fast demarcation between the classes of cocoons mentioned. Usually in quality they merge into one another and frequently overlap.

3. Quality of raw silk produced depends on the machinery and methods of reeling followed. This point has been discussed in detail in sections 67 to 75.

4. Apart from the inherent quality of cocoons, machinery and methods, supervision, care and efforts are necessary to produce high class raw silk and maintain standard.

It will be evident that different countries are able to produce different kinds of raw silk. Moreover different filatures are organised to produce different brands or *chops* as their own specialities. Japanese and some Chinese filatures and some Bengal filatures are at present intended to produce re-reeled raw silk. Hand reeling machines or *charkas* produce different kinds of raw silk inferior to filature products. Therefore there are numerous qualities and kinds of raw silk. To take an example from the Shanghai silk market Buchanan (Shanghai Rawsilk Market) gives a list of 124 filatures in Kaingsu and Chekiang Provinces of China, each with a different *chop*. The Foreign Silk Association of Shanghai officially classifies the raw silk as follows :—steam filatures, Shantung filatures, Minchew Filatures, Tussah Filatures, Tsatlee Re-reel New styles and Hupeh Filatures.

The best in each class is called Grand-Double Extra, Double Extra, Extra A or Extra and the other sub-divisions are Extra, A, B, C or D.

A typical classification of raw silk by a Shanghai exporter (ibid, pp. 29-30) shows 32 kinds of raw silk, each kind has grades varying from 1 to as many as 7, the grades have different *chops* varying in number from 1 to as many as 218 and the total number of *chops* recognised in the market is 1,444.

There are similar difficulties on the part of the consumers i.e. silk weavers. A typical example is the following list of classes of silk known to the silk weavers in the Punjab (Hailey's Monograh of Silk Fabrics in the Pinjab, 1899).

1. *Wardan.*—A name applied to best Central Asian Silk. Price Rs. 12 to Rs. 18 according to quality and place of sale.

2. *Mai, Mayee or Phul.*—A name chiefly given to China silk imported from Bombay via Amritsar. Price Rs. 11 to Rs. 17.

3. *Akhoha.*—From Balkh. Rs. 15 a seer at Peshawar.

4. *Attayan.*—A China silk imported from Bombay. Rs. 15 a seer at Peshawar.

5. *Nawabi.*—From Bokhara. Rs. 12-8 at Kohat and Rs. 14 at Peshawar.

6. *Lab-i-abi.*—Produced in the country bordering on the Oxus and in Samarkand. Sells for Rs. 14 a seer in Peshawar.

7. *Shar-i-sabzi.*—A Samarkand silk.

8. *Waran.*—A Bengal silk. Sells for Rs. 13 or less according to quality.

9. *Namkani.*—A Central Asian silk. Sells for Rs. 13 a seer at Peshawar.

10. *Charkhi.*—A Bokharan variety. Rs. 11 or Rs. 12 a seer.

11. *Ghungru.*—A Bengal silk from Rampur. Sells for Rs. 8 to Rs. 11 according to quality.

12. *Baf Kandahari* and *Baf Yarkand.*—Sells at Amritsar at Rs. 12 and Rs. 12-8 a seer.

13. *Kakra.*—A Hongkong silk. Rs. 11 a seer.

14. *Sultani.*—A Hongkong silk. Rs. 11 a seer.

15. *Berhampuri.*—Produced in Gurdaspur District. The outturn is said to be 2 or 3 maunds per annum. The silk sells at Rs. 13 a seer at Amritsar.

16. *Dukhi.*—A Bokhari silk used in embroidery. Sold at Rs. 11 a seer in Peshawar.

17. *Kattai.*—A China silk, imported via Bombay.

18. *Dutara, Ektara, Lani, Maktul, Kattar.*—Bengal silks from Balli. Sells at Rs. 7 to Rs. 9 a seer.

19. *Manchu.*—A Hongkong silk.

20. *Maithra.*—Hongkong silk. Rs. 3-8 to Rs. 5-2 a seer according to place of sale. A rough silk used on the frontier for embroidery.

21. *Sika* or *Sikha* or *Sikhapari.*—Imported from Singapore. Rs. 4 or Rs. 4-10 a seer. A coarse silk used down-country and on the frontier for embroidery.

22. *Shishmahal* or *Shishmal.*—A Hongkong silk of inferior quality costing about Rs. 3 to Rs. 4 a seer.

23. *Arewa.*—A coarse *Yarkandi* silk costing about Rs. 4 a seer.

24. *Chap, Gora, Lani, Maktul, Lani Chapperi, Kachar, Khambandi, Ladwa, Lambi, Bandi, Radha Nagri, Ateran.*—These are all Indian silks of inferior quality costing from Rs. 4 a seer downwards and used in making *azarbands*, etc.

25. *Dari.*—Silk mixed with flax from Italy.

Under such bewildering circumstances testing before purchase is the only course to be adopted.

The highly devolped silk manufacturing industry in U.S.A. utilises high class graded raw silks and the raw silk is taken after a test in the Conditioning House. The graded raw silks are a class by themselves whose qualities are determined so as to be used for definite classes of manufactures. The superior grades are used for hosiery.

The Japanese Chamber of Commerce, Bombay, classified the Japanese raw silk imports into India as follows :—(Written Evidence, Tariff Board, 1, 1940, p. 1046).

Filature steam white .. below 17 denier.
Filature steam white .. above 17 denier.
Filature steam yellow .. below 17 denier.
Filature steam yellow .. above 17 denier.
Other (evidently dupion and domestic reeled).

Messrs. Nagindas Foolchand Chinai & Co., Bombay, gave the following classifications of their imports (ibid, p. 904-912).

1. Raw silk— A. Japanese filatures white .. 13/15.
   Japanese filatures white .. 20/22.
   Japanese filatures yellow .. 20/22.
   B. Canton steam filatures .. 20/22.
   C. Shanghai Tsatlee Re-reel
   Shanghai Steam filatures .. 20/22.
   Shanghai Shantung filatures yellow .. 20/22.
   D. Hand reels (Native reels).
2. Silk yarn or twisted silk organzine.
3. Waste products (A very coarse silk).
4. Dupions (reeled from double cocoons, a coarse silk).
5. Noils.
6. Spun silk.
7. Nitto mixed (50% spun and 50% rayon).
8. (Artificial silk) Rayon yarn, twisted rayon yarn.
9. Staple fibres.

The Vice-Consul for China, Bombay, classified the raw silk imports from China as follows (ibid, p. 904)

Raw silk— Reeled from dupions.
White not reeled and not steam filature.
Yellow not steam filature.
White re-reeled.
Yellow re-reeled.
White steam filature.
Yellow steam filature.

The following imports are recorded through Karachi port (ibid, p. 1092).

Silk yarn made from silk waste.
Silk yarn made from noils.
Silk yarn others.
Spun silk.
Silk manufacture thread for sewing.
Artificial silk yarn.

A simple workable general classification into which all kinds of raw silk can be fitted becomes very important and especially for the purposes of customs tariff in the case of imports. It has been discussed by the Indian Tariff Board (Report 1934, pp. 126-133) who suggested a broad classification :

No. I Steam filatures.
No. II Re-reeled silks.
No. III Native reeled (on hand machine) silks.
No. IV Waste products and dupion hand-reeled silk.

The second Tariff Board (Report 1940, p. 128) approved of the following classification followed for customs duty. (1938-39).

Article.	Rate of duty.
Silk raw (exlcuding silk waste and noils) and silk cocoons ..	25 per cent *ad valorem* plus 14 annas per lb.
Silk raw—	
Chinese	
Waste products.	
Dupion all kinds.	
Hand-reeled (excluding re-reeled).	
All other sorts.	
Japanese filatures (and hand-reeled and hand re-reeled but excluding dupion all kinds)	
Silk waste and noils ..	25 per cent *ad valorem*
Silk yarn including thrown silk warps and yarn spun from silk waste or noils but excluding sewing thread ..	25 per cent *ad valorem* plus 14 annas per lb.
Silk sewing thread ..	25 per cent *ad valorem*
Artificial silk yarn and thread	

In the above statement the rate of duty also is quoted in order to explain the mistaken classification adopted.

It is a mistake to classify cocoons with raw silk.

(a) Raw silk is reeled out of cocoons and forms about 1/12 to 1/15 part of green cocoons by weight. Manufacturing cost has to be added to cocoons in order to obtain raw silk.

(b) Cocoons being the raw material for production of raw silk are best allowed free as they are of help in sustaining the reeling industry in places like Bengal and Mysore

where production of multivoltine cocoons is intermittent and filatures have to remain idle for a time. Now that the filature industry is being established at great cost this point requires consideration. The filatures may find engagement with imported cocoons. The same is the case with Kashmir when for some reason production of cocoons falls short.

It is a mistake to classify Japanese filature silks with hand-reeled silks.

A scientific classification should be on the following lines. Raw silk classes are mentioned from the best downwards.

I. Rawsilk—

A. Finely reeled raw silk.

(1) Graded i.e., raw silk which falls in the grades from the best down to F in the classification table (Section 79).

In all transactions of the best kinds of raw silk now-a-days the certificate of the results of test in a Conditioning House is required to be supplied and this certificate indicates the grade. There can be no confusion about the graded raw silk.

(2) Ungraded i.e., which does not come up to any grade.

(i) Steam filatures.—The major portion of the filature products of Kashmir, Mysore, Madras, and Bengal and imports from China come under this class at present.

(ii) Hand-reeled.

Finely reeled *charka* silks No. 1 and No. 2 of Mysore and *tana* and *bharna* qualities of Bengal and much of the imports from China, Indo-China, Bangkok, and trans-frontier Asiatic country, come under this class.

B. Coarse raw silk.

(i) Dupion.—Partly produced in Kashmir and imported from Japan mainly and also from China.

(ii) Hand or filature reeled.—The coarse silks from soiled and crushed cocoons of Kashmir filatures, *charka* No. 3 of Mysore and *ghora* of Bengal and some portions of imports from China and other country, come under this class.

II. Silk yarn.—Thrown silk, prepared warps and wefts (organzine and tram) come under this class, mainly imported from Japan and China.

III. Spun silk.—Spun silk pure. The spun-silk mills at Channapatna, Mysore, produce a part. The major portion is imported.

Spun silk mixed.—Mainly imported from Japan.

Noils.—Partly produced in Mysore; the major portion imported.

IV. Silk sewing thread.—Imported.

V. Rayon.—(Artificial silk yarn) imported.

VI. Staple fibre.—Imported.

All kinds of raw silk, silk yarn etc. will come under one or other of these classes. Silk waste is not imported but exported and if wastes are required to be classified they should be (i) cocoons, (ii) reeling waste.

If cocoons are imported for reeling they should be classed as cocoons.

84. How to reel high grade raw silk.

The filatures in Kashmir and Jammu and those being established in Mysore, Madras and Bengal should be able to produce good grades of silk by paying attention to the following points in addition to the rules given in section 70.

1. Cocoons.—Kashmir and Jammu are in an advantageous position as dealing only with univoltine cocoons.

Bengal filatures should try to secure Nistid and Nismo cocoons. As will appear from section 66 the silk content and reelability index of Nistari cocoons are low. Chotopolu has practically ceased to be reared.

In Mysore and Madras F_1 cross cocoons should be secured.

2. Cocoons of uniform lots should be reeled.

3. Defective cocoons should be sorted out and reeled without being mixed with other lots.

4. Before reeling a test should be carried out to determine how many cocoons are required to produce the desired denier of raw silk.

5. Quantities of cocoons should be weighed out which will produce hanks of desired weight and distributed to reelers. This will ensure production of uniform hanks.

6. A strict supervision should be kept on the reelers to see that they feed filaments properly and maintain uniformity in the number of cocoons being reeled. As a further check without previous intimation the denier of the thread being reeled by reelers here and there should be taken on the deniering machine and checked for denier and the denier observed noted on a strip of paper attached to the reel with the identification number of the reeler. This strip should accompany the hank.

7. Cleaning the thread of slugs, etc. adhering to it should be done while the thread is being reeled. In the Ghosh machine the reeling reel admits of this being done and it is further facilitated if two sets of reels are used. The reels with the supporting rod are removed and replaced by another set for the reeler to go on with. The removed set is placed on a stand, cleaned and then returned to the reeling machine, the other set being removed for cleaning. The raw silk of the two sets are re-reeled on one standard reel to make one hank. The number of breakages are noted on the counter while the silk is being re-reeled and its denier is also tested. These and the weight of the twisted hank are noted on the strip of paper and finally entered in the reeling register. The reeler producing raw silk of uniform denier, with fewer or no breakages and giving higher outturn of raw silk from the cocoons should be given a reward in addition to wages. It will be found in the course of a short time that the filature will be able to produce good graded raw silk.

8. In order to ensure uniformity of colour of all the hanks in the book, bale and lot, the practice is to take the re-reeling reel with the silk on it into a room with arrangements for steady north light and observe the colour. Any room can be used by leaving a north window open or fitted with glass and hanging black curtains to keep off light from other directions.

85. Trade in raw silk.

At present there is no export trade in raw silk from India.

In the past Bengal had a large trade and Kashmir and Mysore raw silks had an export market in recent times which however is now closed. Although there is a home market, an export market is necessary in the interest of the expansion of the industry. Marketing of the raw silk done at present in the country is not on scientific lines and far from satisfactory. Marketing outside India will require special methods and organisations to be adopted. The methods followed and required are described below.

Marketing of raw silk at present practised in India :—The major portion of the raw silk is consumed by silk-weavers using handlooms and weaving either pure silk-goods or mixed goods which are mostly cotton cloths with silk borders. Such weavers are scattered throughout India. The raw silk finds its way from the centres of production to the weavers in various ways, which vary from place to place even in the same province.

Bengal :—As explained in section 82 the qualities of silk produced at present are (1) *ghora*, a coarse silk, (2) *tana* and *bharna*, reeled on old hand *charka* and (3) re-reeled silk, produced on machinery recently introduced. A portion of *tana* and *bharna* silks is utilised in the province, the rest being exported to other provinces and States. In the province a small portion is sold by reeling concerns direct to weavers. The major portion of the produce, about 85 to 90 per cent, passes through Marwari merchants or

dealers who frequently advance money to reeling concerns for purchase of cocoons and get raw silk reeled according to order.

The trading practices followed in the case of *tana*, *bharna* and *ghora* silks in Malda where the largest transaction takes place, are of two kinds. In one the dealer acts as a broker, charging *dalali* (brokerage) at Rs. 1-4-0 per cent from the seller and Re. 1 per cent to the buyer, packing and transport being extra charged to the buyer in all transactions. In the other method the dealer buys the raw silk outright at prevailing market rate but charges the usual *dalali* at Rs. 1-4-0 per cent from the reeling concern and stocks and sells it also at prevailing market rate charging however the usual commission at Re. 1 per cent to the buyer. If there be fall in price he may incur loss. The weight adopted while purchasing is 82½ tolas per seer and while selling 82 tolas, although the standard seer is 80 tolas. The extra weight is taken to compensate for losses due to moisture and winding. In Beldanga in Murshidabad district buying and selling weights are 80 tolas per seer but the dealers charge *dalali* at Rs. 1-9-0 per cent and commission to buyers at Rs. 2 per cent plus 1 anna extra per seer of raw silk sold. In Khagra bazar, Berhampore, Bengal, for *tana* and *bharna* silks from Jangipur sub-division buying is done at 82½ tolas per seer without charging any *dalali* but sale is effected at 80 tolas per seer plus Re. 1 to Rs. 2 per seer as profit.

In the case of re-reeled silk buying and selling is done by the dealers everywhere at 80 tolas per seer without any *dalali* from the producers but a commission of 2 per cent from the buyers who are mostly from outside Bengal plus 1 anna per seer sold charged only by Beldanga dealers.

Determination of market rates is an important item in these transactions. This is at present done by the dealer on the strength of the information he collects as to the price expected to be offered by the local as well as outside purchasers. Frequently, however, the dealer has to supply quotations and in the absence of any information as to expected offers the dealer arrives at a rate by taking into consideration the cost of production on the one hand and demand and supply on the other. The dealer therefore keeps information as to cocoon prices. The charges for reeling are fairly well known at the places concerned.

A few reeling concerns sell their produce through their own agencies established in weaving centres. A few again sell direct to dealers outside the province at prices settled between themselves.

Mysore :—The chief market for Mysore silk is Bangalore where there are a number of silk *kotis*. The reeler or the local broker markets his silk through these *kotis* and the silk *koti* generally advances him an amount varying between 50 and 70 per cent of the total value of raw silk deposited with the *koti* and effects sale of the silk on receipt of orders from his clientele either in Mysore State or from outside consuming centres viz. Salem, Conjeevaram, Hubli, Gadag, Dharwar, Dharamavaram and Hyderabad. The *koti* owner charges a commission of 1½ annas per lb. of silk sold. Large consumers sometimes employ their brokers for obtaining silk for their consumption. The broker gets a commission of 2 to 4 annas per lb. which is called *gootum*. The silk is generally consigned in bales of 105 to 108 seers (seer=25 tolas) (Written Evidence, Indian Tariff Board, 1940, p. 795).

Kashmir and Jammu:—The system of sales through agents in India has been given up. The Directors of sericulture of the two places have established direct contact with the dealers in different markets and in a few cases with bulk consumers. Sales are effected by inviting tenders from time to time in the open market. Out of the three Sale Agencies in Europe which existed in 1933 the two functioning on the continent have been discontinued, the only one now left being in London which concerns itself almost exclusively with the disposal of various superior grades of silk wastes whose sale in India is still offering difficulties (ibid, pp. 211-12).

The main reason for the closure of the European market is that this raw silk has failed to compete with Japanese silk in quality.

There is only one spun-silk mill at Channapatna in Mysore. Unless more such mills come into existence silk wastes have to be exported.

The raw silk ultimately finds its way to the silk weavers through dealers and retailers in different centres.

How marketing is done in Japan:—Weaving on a large scale is done of silk fabrics for export outside Japan and such weaving consumes a large quantity of fine standardized raw silk in addition to the products of coarse reeling for fabrics for home consumption. Raw silk for home consumption passes directly from reeling concerns to weavers or indirectly through dealers. Selling is usually done by the net weight of the silk. If too much moisture is observed conditioning is carried out in a Conditioning House and if the difference between the net and conditioned weights be over 2 per cent this difference is deducted. Apart from other tares which are actually weighed approximately one lb. is deducted for strings tying the books for every 133 lbs. or the strings if heavy have to be weighed, any fraction below about 5 oz. being cut off. The weigher gets 50 *sen* per *kori*. Conditioning Houses have been established in important silk weaving districts (prefectures). Prefectural Conditioning Houses also carry out quality tests in some places in the case of fine raw silk. Raw silk for movement in the country is packed in boxes called *kori* and the weight packed in a *kori* is about 74¼ lbs. Raw silk for export is sometimes packed in large *koris* containing about 95¼ lbs. Unit for conditioning and testing in prefectural Conditioning Houses is the small *kori*.

The organization for marketing raw silk for export has two agencies viz. wholesale dealers (*tonya*) and exporters who deal between themselves without any brokers. The majority of reeling concerns send their raw silk to wholesale dealers who carry out transactions with the exporters on commission basis. The dealers are either empowered to effect sales at their discretion or have to consult the concerns as to date, place, price and mode of delivery. A few large reeling concerns carry out sale of their own products. The Japan Federation of Raw Silk Sale Cooperative Societies serves as the selling agent of Cooperative Reeling Societies. Taking all these three selling agencies as wholesale dealers, the number of such dealers registered at present at Yokohama is 46 and at Kobe 33 who are all registered under law. These two places are the silk markets of Japan, both for internal distribution and foreign trade. All exporters have their own laboratory for carrying out visual tests, and a few for carrying out quality tests too. Quality tests are carried out for all others in the Conditioning Houses free of charge. Transactions between the dealers and exporters are carried out on the basis of the certificates of quality tests. When the transactions are completed the silk received in 18 small or 14 large *koris* requires to be packed into exportable bales (=133·3 lbs. each approximately, 5 per cent variation on either side being allowed) in new unwashed linen bags (called shirts). These bales then have to be sent to the Government Conditioning House for conditioning of weight which is compulsory under law. In practice conditioning of weight and testing of quality and grading are done in the Conditioning House at the same time. Some firms have testing arrangements of their own and in their case only conditioning of weight has to be done in the Conditioning House. In the case of a few firms officers from the Conditioning House go to their places and take samples for conditioning. The Conditioning House authorities after necessary operations put a copy of the certificate inside the bale and close the shirt and seal it with a label which serves as a pass through the Custom House, which does not allow any bale to be exported without this pass. In spot transactions delivery of the silk is made within five days at the negotiated price. Forward transactions are for delivery at a fixed future date either at prices previously fixed or to be fixed at a future fixed date. Such transactions are effected according to the Export Rawsilk Regulations drafted by the dealers and exporters and have to be carried out in public and the details registered at the Export Rawsilk Registration Office which publishes a statement of the total number of the transactions and the average price of sale. Deliveries, either spot or forward are made on behalf of the seller at a given place on an agreed date togther with the certificates of quality and conditioning tests and a sample of the silk which the exporter may re-examine if he considers it necessary. The *chop* or label

of the reeling concern is then replaced by that of the exporter and the goods are ready for export when thus re-labelled.

Both dealers (*tonyas*) and exporters are important in the export trade of raw silk. Before the Russo-Japanese war the reeling industry was generally financed by the dealers and prefectural (i.e., district or moffusil) banks. After that war and especially after the World War I urban banks began to finance the industry. After the great earthquake in 1923 the financial centre of the silk reeling industry definitely shifted to the central money markets. At present commercial banks do the largest financing and next to them the wholesale dealers.

There are good fire and earthquake-proof concrete warehouses for storing silk both at Yokohama and Kobe. The Warehouses at Yokohama can accommodate about 80,000 *koris* and are leased to a corporation in which sericulturists and reeling concerns have shares.

Operations in marketing:—The reeling concerns pack in *koris* sufficient raw silk to make up ten bales, the exportable unit or lot and despatch the *koris* to the dealer. If money is wanted immediately the bill of lading and the insurance policy on the lot are presented to the local bank and a documentary bill negotiated usually for 70 per cent of the price of the silk in the lot. The whole set of documents are sent to the dealer and the bank also notifies it to its correspondent bank at Yokohama or Kobe as the case may be. The dealer goes to the latter bank and takes delivery of the lot against the bill of lading and the documentary bill and its interest and then notifies the owner and commences the operations for sale. The dealer contacts the exporter and arrives at some agreement. Then the exporter takes and examines a few books and if satisfied makes a provisional contract as to price and quantity required, and this contract is solemnised by both parties clapping their hands by way of swearing to abide by the contract. The dealer then sends the whole lot of silk to the exporter's godown against the warrant. If the exporter is satisfied after examination the real contract is entered into and after weighment the price is paid off by the exporter. Should the goods prove inferior on examination the contract may be cancelled and the goods sent back to the dealer or they may be accepted with a deduction in the price settled in the provisional contract or the goods may be accepted at price provisionally fixed with the defective portions replaced or discarded.

Dealings in raw silk are always in cash against delivery, no credit being allowed. There is another method of sale through a forward contract in which the quality of raw silk, its price and the date of delivery are specified which the contractors are bound to follow without any variation whatsoever, even if there be wide fluctuations in price at the time of delivery. In one form of forward contract the price is not fixed beforehand but that current at the time of delivery is agreed upon. The Yokohama Rawsilk Exchange allows future transactions, the time limit being five months. Reeling concerns sell their product here for forward delivery at the time they purchase cocoons and thus fortify themselves against loss due to fluctuations in price.

How marketing is done in China :—Here the trade had to develop its own methods and not under Government regulations as in Japan. In the case of internal consumption the silk-weavers obtain their raw silk from the reeling concerns direct. In the case of export trade to foreign countries several important agencies take part in it. Export of raw silk from Central China goes through Shanghai and the following details refer to the Shanghai market.

The important agents are the exporters, who are practically wholly foreigners, namely French, British, Swiss, Japanese, Italian, American and others. A few Chinese have recently undertaken this business. These exporters have a thorough knowledge of the requirements for raw silk consumed in America and Europe and keep themselves informed of the supply, quality and cost of cocoons and raw silk in the producing areas. They maintain laboratories for inspecting and testing raw silk. Until lately with very few exceptions each exporting firm employed a Chinese compradore. At present dealings through brokers are becoming more common.

The compradore must be a man of substance, standing and good repute in the native community and possessed of business integrity, intelligence and honesty. He is provided by the employing firm suitable office-quarters and suitable and sufficient godowns as he has to assume full responsibility and liability for all raw silk placed in the godowns. He is further responsible for mistakes in the receipt and issue of raw silk and liable for all money, treasury notes, bills, cheques and securities received or paid out by him on behalf of the firm as well as for the payment when due of all native bills, drafts, bank orders, etc. He has to put up collateral security with the firm, partly in cash and partly in approved title deeds to real property. He receives from the firm a fixed salary per month which includes the wages of the staff he employs as well as a fixed scale of commissions.

The exporting firm issues detailed reeling instructions to the filatures which after reeling the raw silk according to these instructions deliver it into the compradore's godowns in lots of at least five bales of a particular size and classification. After inspection and test to ascertain if its quailties are up to standard the raw silk is either accepted or rejected. Between the exporting firms and the filatures there is another important agent namely the silk broker.

Silk brokers act as middle-men or rather agents to negotiate sales of raw silk between the filatures and the foreign buyers and the contract for immediate or future delivery of silk is signed and payment received by them on behalf of the filatures. The brokers maintain their own offices and godowns and they are frequently known as storage-houses instead of brokerage firms. The silk broker after preliminary negotiations deposits the silk in the godown of the exporting firm and receives a receipt for it, under the following conditions, namely: (1) The silk is held by the buyer as agent for the seller who is deemed to remain the owner of the goods. (2) The silk must be insured by the buyer against loss or damage up to the approximate purchase price. (3) If on inspection the silk is rejected for inferiority and the seller notified about it the buyer ceases to have any further responsibility and the seller has to remove the raw silk. (4) If approved the buyers' responsibility continues on the express understanding that the property in the silk shall not be transferred to the buyer until it is fully paid for and that until fully paid for the silk shall not without the consent of the seller be hypothecated by the buyer who is also debarred from raising any money upon it or to dispose of it, except for shipment under the customary conditions of the silk trade of the port. Payment is made for the silk the day after the ship sails. For the services rendered the broker charges a commission on each *picul* of raw silk sold according to the following general schedule in *taels* (=·7 Gold Dollar)

	Taels.
White Steam filature silk	3.75 per picul.
Tsatlee Silk (including storage etc.)	3·90 ,, ,,
Yellow Filature (including package)	6·00 ,, ,,
Tussah Filatures (including package)	3·75 ,, ,,

The schedule of commission charges varies in the case of steam filature raw silk from different districts. After the silk is inspected and tested and the quality found to be satisfactory the sellers are notified of the acceptance and are requested to supervise the weighing of bales in the exporters' godown. When weighing, the five sample skeins drawn previously for testing and two additional specimen skeins taken from a five bale lot for the buyer abroad are not included. Out of the five skeins for testing what is left after the testing operation is returned to the owner and what is consumed in the test is considered and retained as waste by the laboratory. The weighing balances are customarily read to one-half pound accuracy and in some places one-quarter pound. The tares consisting of the shirts, papers, strings and *chop* tickets are calculated and deducted. After weighment professional packers pack the bale in shirt with wrapping papers, then oiled paper and then matting at specified charges. The packing charges are met by filatures. After packing the bales are stencilled with necessary marks, bale number, gross weight and the destination and then despatched to the shipping company's godown and acknolwedged by a receipt which is later replaced by the bills of lading.

In the absence of Government test houses and international grading as in Japan the Foreign Silk Association of Shanghai adopt the following classification according to quality in the order named :—

Steam filatures— Grand Double Extra
Double Extra
Extra A.
Extra B.
Extra C.
Good A.
Good B.

The best *chop* of—
Shantung filatures— Double Extra.
Minchew filatures— Double Extra.
Tussah filatures— Extra A.
Tsatlee Re-reel new style—Double Extra.
Hupeh filatures— Extra and the inferior qualities of these in the same way as in the case of the steam filatures.

As regards inspection and testing the methods followed in different laboratories are different depending upon the requirements of the consumer.

The visual inspection of course is important. Inspection for colour, cleanness and feel is done with eyes and hands on the basis of long experience. The two most important mechanical tests are sizing and winding. Five hanks are drawn from each bale of steam filatures and from every two bales of tsatlees. The winding test is usually run for two hours. The result is recorded in tavelles. From 0 to 8 breaks the tavelle is 100. From 9 or more breaks the tavelle is $\frac{\text{No. of breaks} \times 100.}{80}$ The size is determined on 20 sizing skeins taken at the rate of 4 from each hank. Occasionally tests for strength, elasticity and evenness and cleanness are made. Recently the seriplane has been introduced, 30 panels being taken from each five bale lot. The exporter issues a certificate which is sent to the buyer abroad.

These methods were followed before the establishment of the Shanghai International Testing House completely equipped on modern lines in 1922 mainly at the suggestion and with the help of the American silk manufacturers. A testing house was later on started for Canton silk also and the Chinese Government enforced compulsory testing and conditioning of all raw silk for export.

86. How an export trade in raw silk can be developed in India.

1. The first necessity is arrangement for testing and conditioning. The filatures have to become used to the Conditioning House methods and without this they cannot be expected to be able to produce raw silk in bulk in grades which can compete in the international markets. The root cause of the failure of Mysore and Kashmir in their attempts at developing an export trade in recent times lies here and the loss of Bengal's old export trade is also mainly due to the same cause.

2. The second necessity is an agency like the silk brokers of China or wholesale dealers (*tonyas*) of Japan at the exporting points which are best located for Bengal at Calcutta, for Mysore and Madras at Bangalore and for Kashmir and Jammu at Srinagar with arrangements for testing Jammu silk here.

3. The third necessity is some exporting firms with connections in consuming countries viz. U.S.A., Canada, European countries and Australia. Foreign firms are expected to open business at the exporting points if raw silk of internationally acceptable grades can be produced and marketed in bulk.

PART VII.

BY-PRODUCTS OF THE SILK INDUSTRY.

87. Silk wastes and their kinds.

THE by-products of the three stages of the industry are different and utilised in different manner as described below.

In the first stage (*sericulture proper i.e. cocoon production*) :—Properly speaking cocoons from which fine raw silk can be reeled out are desired as the products of this stage. But along with them the following are obtained and included among what are generally spoken of as silk wastes.

(1) Floss (called *fenso* in Bengal) consisting of loose filaments which the worms use as cradle for the cocoon in the cocoonage and also of the loose filaments sticking to and covering the cocoons. This covering is peeled off before the cocoons are utilised.

(2) Pierced cocoons (called *lat* in Bengal) from which moths are allowed to cut out for the purpose of obtaining seed (eggs). Cocoons from which moths cut out through want of stifling in due time and which are damaged by ants or rats or the parasitic fly fall under this category.

(3) Flimsy cocoons (called *chera* in Bengal) generally forming a very small proportion of the cocoons reared.

(4) Crushed cocoons in which the crysalis is crushed and soils the stuff.

(5) Double (called *gente* in Bengal) cocoons in which two worms together spin a single cocoon. The filaments get so much entangled that they cannot be used in fine reeling to give good raw silk. Double cocoons are produced by univoltine races of worms and not by multivoltine ones viz. Nistari and Chotopolu races of Bengal and Mysore race of Mysore and Madras. The univoltine Boropolu race of Bengal also does not produce them. Hybrid races such as Nistid and Nismo of Bengal obtained through hybridisation between univoltine and multivoltine races although fixed as multivoltine produce double cocoons to some extent. The percentage of double cocoons in a lot is small about two but in some cases may amount to as much about seven. Their number can be kept down in the case of hybrids through care in not breeding from moths issuing out of double cocoons.

(6) Cocoons known as *gazla* in Bengal i.e. those spun by worms during periods of pouring rain in the rainy season. Such cocoons do not reel properly and cannot be used in fine reeling. Univoltine cocoons do not suffer from this defect as they are never reared in rainy season.

In the second stage i.e. reeling :—(7) Long wastes also known as frissons or kneebs (*jhoot*) being the first layer of silk on the cocoons pulled off in finding and getting at the ends of the continuous filaments before starting reeling. This waste is important as the chief by-product of reeling and as a valuable raw material for the spun-silk industry. It is pulled out evenly in wet condition, loosened, cleaned and carefully prepared by waste preparers at the same time as reeling goes on.

In Bengal a method of preparing this waste in the form of long tapes ordinarily known as *chasam* by the reelers themselves at the end of the reeling of a lot of cocoons is still in vogue. The defect of this method is that the tapes contain sticks, chrysalids and exhausted cocoons and they require to be opened and cleaned in the spun-silk mills before they can be utilised. Loose, clean long wastes are therefore preferred and fetch a higher price than tape waste. For this reason the tape waste is frequently split open and cleaned with hand before export. The process is called *farai* i.e. splitting open and the tapes lose about one-third of their weight in the process. Cleaning is more easily done in preparation of long waste in the wet condition directly from reeling basins. *Farai* is an unnecessary and costly process.

(8) Short wastes, also known as frissonettes, crapands or curleys, being short lengths obtained during actual reeling of the cocoons.

(9) Exhausted cocoons, known as *topa* in Bengal being the core or innermost part of the cocoon shell from which reeling of the filament now very thin, is not possible. When not in use in any local home industry, for instance, in *matka* spinning in Bengal, the *topas* are dried and then beaten with sticks to pulverise the dry chrysalids which are thus separated before the silky waste can be marketed.

(10) Dropped cocoons i.e. cocoons which for some reason or other do not reel in the reeling basins.

(11) Re-reeling waste, also known as gum waste, consisting of bits of silk thread rejected in re-reeling where re-reeling is practised.

In the case of multivoltine cocoons in Bengal the proportion of reeling wastes to raw silk varies in different seasons. Thus for raw silk produced the proportion of waste, in *Agrahayani* (December) crop is about 50% in country basins and 63% in filatures, in *Choitra* (April) crop about 63% and 75% and in rainy season crop about 75% and 100% respectively. In the case of univoltine cocoons of Kashmir and Jammu this proportion varies from 36% to 45%. In the dry seasons proportion of waste in the case of Nistid and Nismo cocoons is about the same in Bengal.

In the third stage:—(12) Throwsters' waste in processing of the silk thread for manufacture of fabrics etc. and in actual weaving waste is obtained in the form of thread rejected. Wastes from twisted yarn should not be mixed with it.

88. Utilisation of wastes.

Flimsy, crushed, double and *gazla* cocoons are used in coarse reeling producing a thick, uneven silk.

Flimsy and crushed cocoons are reeled in Japan on the hand-reeling machine (*Zaguri*) and is known as *Zaguri-ito*.

Double cocoon reeling is now practised extensively in Japan and such cocoons are also imported for the purpose from China. The thread produced is known as dupion silk and the machine used in reeling is of the Zaguri type (see *Silk Industry of Japan*, pp. 32-33).

Flimsy, crushed and *gazla* cocoons are reeled in Bengal into what is known as *ghora* silk which is of the type of dupion silk. The machine used is the hand *charkha*.

All other wastes form raw materials for spun silk produced in spun-silk mills. But much of the pierced cocoons is utilised in different countries in different ways as described below.

Mawata in Japan—*Mawata* is a sort of loose pad, formed from the cocoon layers stretched after being softened with soda. *Mawata* is made into vests or used as linings of kimonos for use in winter. It is of two kinds, viz. ordinary *mawata* of square size and *fukuro* or pocket *mawata* of the shape of a bag. Square *mawata* again is made into two sizes, small about 9 *sun* or $11\frac{1}{3}$ inches square and large 1 *shaku* or about $11\frac{1}{2}$ inches square.

Cocoons, two litres by measure (about 2 kilograms) are boiled with two *momme* (7 grammes) of washing soda. Then they are washed in plenty of water until the dirt is removed. Washing is done mostly by pressure in order not to entangle the fibres of cocoons. Then each cocoon is taken up singly and by inserting the fingers through the opening it is reversed and the pupal and larval skins are removed. After this it is stretched with the fingers of both hands into a square or a pocket as desired. All this operation is done under water. Square *mawatas* are got into proper size by fitting them on to four pins at the corners of a square frame or board.

For small square *mawatas* three cocoons are worked into one layer, i.e., three cocoons are taken one upon the other and then stretched together and three such layers or 9

cocoons in all go to make one piece. Large square *mawatas* also are of three layers but each layer is made of four cocoons.

Each piece of pocket *mawata* is made of 9 cocoons. Pocket *mawatas* are rather difficult to make and are made from good cocoons. They fetch a little higher price than square ones.

After formation each piece is squeezed between the hands to expel the water and then stretched and dried.

In China pierced cocoons are similarly used in making quilts and padding for wearing apparel in winter.

Matka in Bengal :— Pierced cocoons are soaked in a solution of pea or lentil meal in cold water overnight and then spun with hand spindle (*taku, takuri* or *takli* Fig. 90)

FIG. 90—Spinning *matka* thread with *taku* or *takli* (hand spindle). When the spindle is full, the thread is transferred to the swift on the left.

the resultant thread being known as *matka*. The short lengths spun at a time are wound on the handle of the spindle and when the handle is full the thread is transferred to a swift. Spinning is done as a leisure-time work in the middle of household duties by the womenfolk of mostly poor families. About 15,000 women are at present known to spin *matka*. When the supply of pierced cocoons falls short in Bengal such cocoons are imported from Mysore and Kashmir. A custom has developed in *matka* spinning according to which a small merchant usually goes about distributing cocoons by weight to each family and collects the resultant *matka* thread after about a week and makes payment as wages of spinning. The thread is usually sold on market days in the market to weavers who specialise in weaving *matka* cloths.

89. Trade in silk wastes.

The reeling wastes form the major portion of the raw materials for spun silk. Between 1935-38 Messrs Gono Ltd. exported the following kinds of wastes from different places, mentioned in order of quality as evident from the prices paid for them (Tariff Board, Written Evidence, 1940, p. 973).

Kashmir :—

Sarnakh special	...	... A.
Sarnakh special	...	... B.
Gudar	...	... No. 1.
Nimgudar		
Basin refuse		

Mysore :—

(1) Boiled cocoon.
(2) Reeling waste.
Home silk waste No. 1.
Home silk waste No. 2.
Filature waste.
Frissonettes.

Bengal :—

Struza Bengal No. 1 ... (An inferior waste).

Assam :—

Tussah waste ... (Apparently an inferior *muga* waste).

90 The spun silk Industry

Manufacture of spun silk from silk waste is a mill industry and its success depends on (1) efficient machinery and methods, (2) efficient organisation and (3) availability of suitable wastes. That suitable wastes are available will be evident from the fact that Indian silk wastes have long been exported to Europe for being used in spun-silk mills there. The raw materials which are used in spun-silk mills consist mostly of the reeling wastes of silk, to a less extent of throwsters' wastes and also unreelable cocoons of silk, *eri* silk, *tasar* silk and *muga* silk.

In India some years ago the David Sasson and Alliance Mills and the Chhoi Silk Mills started manufacture of spun-silk yarn with cotton spinning machinery modified for the purpose. Although spinning of silk waste involves processes akin to a combination of cotton and worsted spinning the modified cotton machinery did not evidently meet the requirements of waste silk spinning and the venture proved unprofitable. The Chhoi Mills plant was purchased in 1943, by a new syndicate, Jaya Spun Silk Mills after remaining idle for more than twenty years.

After preliminary trials carried out since 1928 as to the suitability of the silk wastes of Mysore and investigations both in Japan and Europe by Mr. K. Shamshuddin Khan, Assistant Superintendent, Mysore Department of Sericulture, the Mysore Spun Silk Mills Ltd. was started as a joint-stock company in 1936 with the patronage and support of the Mysore Government and with an authorised capital of Rupees ten lakh and issued capital of Rupees eight-and-a-half lakh of which ten per cent was subscribed by the Government which reserved certain powers of supervision and control over the management. The factory has been located at Channapatna and all the machinery from England was received by April 1938 and erection completed in the same year. It is equipped with a plant for spinning noil which is obtained as a by-product in the manufacture of the spun-silk yarn. The plant has 3,000 spindles which are considered to be an economic unit and is capable of utilising about 300,000 lbs. waste and producing about 80,000 lbs. spun yarn and 60,000 lbs. noil yarn annually. During the war the factory has been working to full capacity.

Operations in a Spun-Silk Mill.

I. *Degumming and Conditioning.*

Degumming :—The raw material is steeped in hot water in vats for 3 or 4 days, boiled with soap or soda, beaten with hammers in the stampedo, washed and dehydrated in hydro-extractor.

Drying :—The washed material is then thoroughly dried in drying chambers by hot air.

Conditioning :—The dried material is then heaped in the conditioning room until it regains about 11 per cent of moisture and becomes supple.

II. *Dressing.*—

Suppling.— Done in the suppling machine.

Opening.— Done in the opening machine.

Filling.— The opened out material forms a lap round the drum which is cut into staples which are arranged on sticks for the dressing machine.

Dressing — The material hanging on the sticks is subjected to combining against a cylinder thus removing short fibres and impurities and this operation is repeated for four times in successive machines each time the material being cut and arranged on sticks. The combed out stuff goes to make the noil yarn.

III. *Preparatory process* :—Consists in repeated processes of spreading the dressed drafts, setting, drawing slivers and roving, all intended to get the fibres parallel to one another.

IV. *Spinning* :—The roving is drawn into yarn.

V. *Doubling* :—Two ends are wound on bobbins.

VI. *Twisting* :—The doubled yarn is twisted.

VII. *Gassing* :—The twisted yarn is passed through a series of gas flames to burn away loose fibres and knubs, the ashes being removed by friction over runners.

VIII. *Controlling* :—The yarn is then passed through close gauges which catch up knots and thick portions.

IX. *Reeling* :—Finally the yarn is reeled into hanks.

X. *Baling* :—The hanks are folded and twisted and pressed into bales.

Noil yarn :—The stuff combed out in the dressing process described above, really as a by-product of the spun-silk industry, is opened in opening machines and then passed through hopper to condenser bobbins from which noil yarn is spun in the noil spinning frame.

PART VIII.

ERI SILK.

91. The *eri* silk industry in Assam.

ERI silk is known as Assam silk or Palma christi silk in English and as *eri*, *endi* or *erandi* locally. A general idea of this silk has been given in the sections 2 and 3 and the life history of the worm producing it illustrated in Fig. 5.

Assam valley has been the home of this silkworm from time immemorial. It is not known to occur anywhere else in the world. Although attempts have been made to introduce and establish its rearing as an industry in other parts of India as well as in other countries, they have not been crowned with success. Attempts are still made off and on. A study therefore is worthwhile to find out and know its real characteristics, how and where it is possible to be established and the directions in which action has to be taken for this purpose.

As an industry *eri*-rearing has continued to exist in practically the whole of the Assam valley and in the neighbouring districts in the western part of Bengal. In Assam valley proper there is no religious prejudice against the rearing of this and the *muga* worms which are considered sacred. The principal rearers of *eri* silk are the animistic tribes inhabiting the sparsely-cultivated regions on the northern and southern outskirts of the valley which are mostly hilly or submontane. With the comparatively civilised people living in the centre of the valley, mostly Hindus and Hinduised tribes now carrying on cultivation of the land for crops or other new occupations yielding greater profit, the precarious business of rearing this worm finds less favour than before. The tradition however continues and those who still rear these worms do so mainly for their own use. The annual production in their case is about 2 lbs. of empty cocoons per family. Among the hill tribes on the northern border individual rearings yield about 4 to 8 lbs. while in the southern border about 40 lbs. in the year but the average per family in the area will be about 10 lbs. per year. This indicates clearly the cottage nature of the industry. The rearing of the worm has been an additional attraction for the animistic tribes in that they cherish the pupa or chrysalis of the worm as an article of food almost as dearly as fish.

The worm is yellow and spotted in young state and grows to a large size and when mature measures about four inches in length and about three-fifths inch across and is then either white or green in colour and may be black spotted or without spots. These variations are of no practical importance. The cocoons produced are either white or brick-reddish in colour but white ones are preferred and fetch a higher price. Red cocoons can be eliminated by breeding from moths from white cocoons only. As found out by carrying out mongrelisation experiments at Pusa by the writer between this insect and *Attacus cynthia*, a very near congener, the origin and prevalence of red cocoons in Assam seems to be due to crossing of *eri* by *cynthia* moths which occur wild in the *eri*-rearing regions. Frequently *eri* moths are exposed outside to be mated with vigorous wild males and thus wild *cynthia* males have the chance of mating with them. Although the *eri* worm is multivoltine and can be reared throughout the year yielding about seven or eight crops of cocoons, the principal rearing is done in autumn from about September to November and in spring in February and March when the climate is most suitable and the flypest is less troublesome. In other seasons rearing is done on a small scale mainly to maintain the stocks.

Food of the worm :—Castor (*Ricinus communis*) leaf is the most important food on which the worms are fed. Next to it but far below in importance is the leaf of *keseru* (*Heteropanax fragrans*). Worms fed with *keseru* leaf are said to produce smaller but more compact cocoons than those fed with castor leaf. The worm can be kept alive in emergency with the leaves of the following viz. Cassava (*Manihot utilissima*), Papaya (*Carica Papaya*), *Gulancha* also called *Champa* in some places (*Plumeria acutifolia*),

Gameri (*Gmelina arboria*), *bhot-odol* or *sankru* (*Jatropha multifidea*), *bajarani* (*Zanthoxylum Rhetsa*), *thebow*, a species of dioscorea (*Hodgsonia heteroclita*) and *korha* (*Sapium eugeniafolium*). The first three are cultivated and the rest are wild. Rai Shaib M. N. De, adds sweet potato, cabbage and *sissoo* (*Dalbergia Sissoo*) leaves to the above list.

In upland tracts of Assam where shifting *jhum* cultivation is practised castor is sown along with other crops some distances apart. *Jhum* is usually given up after two years but the castor continues to grow for another year or two until choked up by fresh growth of jungle. In the plains castor is grown in patches in unoccupied lands round the cultivators' homestead. There is a popular superstition against sowing castor seed with hand in some places. In a new place therefore bunches of ripe fruits are hung on a pole stuck in the land. Seeds drop and sprout. The varieties grown are perennial and live for two or three years or more. Even when they die out through water logging self-sown seeds sprout and grow into trees.

The *keseru* tree is both cultivated and wild. In some places it is extensively grown on embankments round homestead lands or in regular plantations 8 to 12 ft. apart and affords the chief food supply for the worm. The tree is either grown from cuttings about 2 ft. long taken from one year old wood or from seedlings from self-sown seeds which are transplanted into permanent positions. Protection against cattle is necessary for tender trees which take about four years to grow sufficiently when the top is cut off to induce branching. Leaves are plucked from about the fifth year. Annual pruning or rather pollarding is given in the beginning of the cold weather otherwise excessive flowering and fruiting take place which is considered harmful to the tree itself. The leaf is considered suitable for use as food for the worm only from about August to December and is too tender in the other months. The worm can easily be shifted from *keseru* to castor leaf but those fed on castor do not take readily to *keseru*. *Keseru* trees live for an indefinite age. A full sized tree may yield upto four or five maunds of leaf. An acre with trees $12' \times 12'$ apart may yield about 500 maunds of leaf.

Egg supply :—The rearer generally uses his own eggs or borrows seed cocoons and when the moths have emerged the empty cocoons are returned. In Goalpara and south Kamrup eggs are sold in the market at about three, four or upto ten layings per pice. The pairing moths are placed on a stick or roll of straw, the female being tied with a string passing under the shoulder joint of the right wing. In some places they are made to hang in folds of a hanging cloth or placed in a basket. On the day following the males depart or are separated and thrown away. The females lay eggs on the stick or straw roll or on the cloth and basket and are allowed to do so for three days after which they are thrown away and the eggs scraped off, tied in a piece of cloth and hung up under the roof until they hatch.

Rearing :—The cloth containing the eggs is opened and placed on a tray and leaves supplied. Worms hatching for three days are taken for rearing and transferred to the rearing trays with the leaves on which they crawl. The trays are covered with a cloth and hung from roof as a protection against flies, rats, etc. Food is supplied three times daily and four or five times during the last age. In some places the worms are not fed on trays in the last age but transferred to bunches of leaves tied together by their stalks and hung saddlewise on horizontal bamboo supports, fresh bunches being placed touching the old ones when consumed. Many worms drop down which have to be picked up and replaced on the bunches. When ripe for spinning the worms crawl to the edge of trays or up to the stalks of the leaf bunches and are picked and transferred to *jalis* for spinning cocoons. The *jali* consists of dry plantain leaves or twigs with withered leaves of mango, jak, etc., tied in a bundle and hung from the roof indoors. Cocoons are removed from the *jali* after 3 days in summer and six days in the cold season. Rearing is done in a corner of the dwelling house or in a compartment of the house separated by a partition. The houses are thatched huts made with the walls of split bamboos or reeds plastered with mud. The duration of the life cycle of the worm, from egg to egg, is about six weeks in summer and 12 weeks in winter.

Treatment of cocoons :—After the cocoons are removed from the *jali*, the animistic tribes take out the pupa from them by widening the natural opening at one end, shaking

out the last skin of the worm at the same time. Such cocoons are the cleanest and the best. Hindu and Muslim rearers having animistic neighbours get their cocoons cleaned in this manner free of charge. Others expose their cocoons in the sun thus killing the pupa inside. Cleaned cocoons weigh about 1,125 to 1,800 to the lb. Cocoons for export are cleaned.

Utilisation of cocoons:—The greater portion of the cocoons reared is spun into thread and woven into cloth by the rearers themselves. Only a small portion is sold in *hats* or periodical village markets where Marwari merchants buy and export them. Cocoons containing dead insects sell at about half the price for empty ones.

For spinning, the cocoons are boiled for about two or three hours until the fibres are loosened in an alkaline water prepared from ashes of plantain stems, castor stems and leaves, *keseru* wood or mustard and *mati-kalai* (*Phas olus*) plants. Ashes about half as much as the cocoons to be boiled, are placed in a bamboo mat funnel and water poured on them, the filtrate water being caught in a vessel below. After being boiled the cocoons are wrapped up in green arum or plantain leaves and left for three or four days. If the fibres are not thoroughly loosened in this manner the cocoons may have to be boiled again in alkali water. Then they are washed in water and opened out under water into the form of a disc, any part of the insect still remaining being removed. Then they are dried out and stored until required for spinning.

Spinning is done in three methods:—(1) A number of cocoons is arranged one over another on the top of a short stick and moistened with water. This stick is held in the left hand and small wisps of the fibres pulled with the right and fed to the spindle known as *taku, takori* or *takli* (Fig. 90).

(2) A number of dry cocoons are carded out with hand and the carded mass arranged into a bunch which is tied to a post and wisps of the fibres are pulled out and spun dry with spindle as in the first method.

(3) Cocoons are arranged on a stick as in the first method, moistened with water and pulled out with hand into a long strand which is allowed to drop into a cup of water. This strand is then removed from water and twisted on the ordinary spinning wheel.

The thread produced in the first two methods is better than in the third method. Weaving is done on ordinary local handlooms and dyeing of the thread where practised is done by the weavers themselves.

92. Attempts at growing eri silk on a commercial scale.

In 1873, Mr. C. H. Lepper, an agent of Messrs Lister and Co. of Bradford, planted about 30 acres with *keseru* in Lakhimpur District. Although his first rearings seemed promising those done with paid labour proved too costly and the attempt was abandoned.

In 1884, a tea planter of Nowgong tried an experiment with castor but without success. In 1886 the Local Government offered to pay half the cost of any experiment in growing *eri* silk on a commercial basis. Several planters made the experiment but none was able to carry it on to completion. In one case the castor plants were washed away by flood. Mr. A. C. Campbell, Deputy Commissioner of Kamrup carried out an experiment with promising results at his own cost of rearing worms with leaves purchased from outside. The following year he planted 20 acres of castor which however did not grow well and he had to depend on outside leaf but with disastrous results, the worms dying of disease in which pebrine was detected. In 1889, Mr. F. Mackenzie, a tea planter of Cachar who had been making experiments with *eri*-rearing for some years past, entered into an arrangement with the Government that the latter would pay him half the cost of an experiment upto Rs. 1,500. In January 1889 about 30 acres were cleared of bamboo and long grass jungle and 20 acres planted with castor on a spur of the Jaintia Hills partly with Patna and partly with Cachar varieties. The plants grew well but the Patna varieties especially began to die owing to excessive rainfall natural to the place. In July the leaves of the surviving castor were devoured by

swarms of caterpillars issuing out of the jungle. The worms under rearing were supplied with *kesera* leaf but all died with symptoms of flacherie disease. A lot which had been fed on *kesera* leaf all along also died with the same symptoms just before spinning. Evidently the season of rearing was unsuitable on account of high rainfall here. The details of all these experiments will be found in H. Z. Darrah's Note on Eri Silk in Assam, 1890.

93. Attempts at establishing *eri* silk industry in other parts of India.

Bengal :—Rearing of *eri* silk and spinning of the cocoons into thread with the hand spindle (*taku*—Fig. 90) is carried out for many years as a cottage industry in the eastern districts, Mymensing, Bogra, Dinajpur, Rangpur and Chittagong hill tracts. Castor is grown generally on homestead lands and rearing on a small scale is done usually by old women who also do the spinning and sell the thread to Marwari merchants who export it to Assam to be woven there. Recently an effort is being made by the Sericultural Department, Bengal, to encourage rearing, spinning and local weaving in Mymensing district and as a result even upper class families have been taking interest in it. The cottage nature of the industry is maintained. As more cocoons are being produced by individual families or persons than can be spun by them, spinning is being encouraged by others on the lines *matka* is spun (see section 88). The Pusa spinning machine has been introduced and is liked by some though the hand spindle (*taku*) is is preferred as spinning can be done with it anywhere even when tending cattle in the fields.

Bihar : A. *Rearing at Pusa :*—Experimental rearing which was later on expanded to a large-scale one, was started in March, 1907 in the Agricultural Research Institute, Pusa. The rearing was done on the leaves of castor. Full records maintained of seventeen broods reared upto the end of 1909 are published in Vol. IV, No. I of the *Entomological Memoirs of the Imperial Department of Agriculture in India* by H. M. Lefroy and C. C. Ghosh. The details of the life and habits of the worm with coloured and other illustrations are given in this memoir from which the following important facts are taken.

Consumption of food by the worm :—By giving weighed quantities of fresh leaf every day to several worms throughout their life and noting rejections it was found that worms yielding one pound of pierced cocoons actually ate about 53 lbs. of leaf substance without large veins or stalks. By weighing the food given to the worms under rearing on a large scale it was found that worms producing 1 lb. of pierced cocoons required 70 to 82 lbs. of leaf as gathered from the field when they could live, feed and spin normally. When there was mortality or when leaves dried up quickly on account of dry winds or when the life of the worm was lengthened by cold more leaf had to be used with comparatively decreased outturn of cocoons.

Life of the worm :—From about the middle of June to about the middle of October which coincided with the rainy season of the locality with a rainfall of about 60 inches in the year the worms fared well completing their life cycle from egg to egg in about 40 days. During this period by proper feeding with fresh leaves about 75 to 95 per cent of the worms hatching out from eggs could be successfully reared to maturity. Rearing was not so successful during the rest of the year. In the cold weather the life period was lengthened and the maximum observed was fully three times as much as in the rainy months. The worms did not fare well when it was hot and dry or cold. The temperature suitable for rearing the worms is between 60°F and 90°F. The worm may stand temperatures down to 50°F or upto 100°F with some difficulty but it suffers if the temperature goes beyond these figures. Moths lay eggs well, eggs hatch well and the worms spin well between about 70°F and 75°F.

Cocoons :—Under favourable conditions the worms spin large cocoons measuring about $1\frac{1}{5}$ inch in length and about $\frac{7}{8}$ inch across the middle part. When worms suffered from cold or heat or starvation they spun poor cocoons which in pierced condition

went about 1,800 to 2,000 to the lb. Empty pupal shells and the last skins of the worms which remained in the pierced cocoons formed about 16 to 20 per cent of the weight of the pierced cocoons. In poor cocoons they formed upto about 25 per cent. Cocoons reared under favourable condition at Pusa weighed about

170 to the lb. in live condition but about 13 days old.

487 to the lb. in dried unpierced state.

1,000 to the lb. in pierced state i.e. when moths were allowed to emerge from them. The best pierced cocoons weighed 854 to the lb.

1,166 to the lb. cleaned of all insect remains.

The proportions approximately were :—

Green : dry unpierced	=3 : 1
Green : pierced	=6 : 1
Green : cleaned	=7 : 1
Dry unpierced : silken shells	=3 : 1
Dry pierced : silken shells	=1·2 : 1 =1·3 : 1
Silken shell : degummed hand spun thread	=2 : 1 (common) =1·6 : 1 (best)

Cocoons in the same lot vary in weight. Thus in a fairly good lot reared the best went 875, the worst about 1,346 and all on the average 1,077 to the pound in pierced state. The worms probably inherit this character from their birth as evident from the smaller size of the eggs laid on succeeding nights. *

Eggs :—Moths require to be allowed to mate for about 24 hours in order to be able to lay fertile eggs. Different moths have been observed to lay from 124 to 415 eggs in all. Egg-laying usually starts on the evening following the day of emergence and is continued every night for seven or eight days. Eggs laid on the succeeding nights are smaller and lighter in weight as will appear from the following statement from the records of two moths :—

Date 13·IX	Moth emerged and laid.	Weight of the eggs per 100 in grains.	Moth emerged and laid.	Weight of the eggs per 100 in grains.
14·IX	73 eggs.	3·4	...	...
15·IX	9 ,,	2·9	65 eggs.	2·84
16·IX	141 ,,	2·9	38 ,,	2·76
17·IX	98 ,,	2·72	27 ,,	2·64
18·IX	21 ,,	2·5	20 ,,	2·5
19·IX	19 ,,	2·4	19 ,,	2·4
20·IX	9 ,,	2·3	11 ,,	2·4
21·IX	7 ,,	...	26 ,,	2·0
22·IX	1 egg	...	7 ,,	2·0
	378		213	

Therefore the practice in Assam of keeping only the first three nights' eggs and worms which hatch on first three days from a batch of eggs seems to be sound. If sufficient moths are available it is advisable to keep only the first day's eggs for rearing. When a large number of moths are available about 80 eggs per moth may be obtained on the first day or if eggs laid on first two nights are kept about 160 eggs per moth may be obtained. According to the health of the moths an ounce will contain about 15,000 to 17,500 eggs laid on the first two nights. If conditions be favourable and about 95 per cent of the worms hatching from these eggs are reared, about 90 lbs. green live cocoons may be obtained which will weigh about 30 lbs. in dry unpierced condition,

about 15 lbs. in pierced condition and about 12·5 lbs. in cleaned condition. The worms will consume about 1,050 to 1,200 lbs. (about 13 to 15 mds.) leaf. This is what can be expected under the best conditions. The results will be poorer in proportion to the worsening of the conditions. If rearing is continued successively from the same worms at one place they deteriorate and become weak and develop a proneness to mortality. Therefore it is necessary to change the seed if possible every year if not oftener.

Castor :—Many varieties were grown at Pusa but not botanically classified. Some had green stems with or without wax, others had red stems similarly with or without wax. They differed in leaf yielding qualities. Perennial varieties had to be sown at least six feet apart in order to allow of branching. Otherwise they grew tall. As regards yield one plot lasting nine months yielded at the rate of about 5,000 lbs. (61 mds.) leaf and 820 lbs. (10 mds). seed per acre. This plot suffered heavily from the attack of castor semilooper caterpillar. Another plot lasting 16 months yielded at the rate of 6,560 lbs. (80 mds.) leaf and 868 lbs. ($10\frac{1}{2}$ mds.) seed per acre. Calculating at the rate of 80 lbs. leaf for a pound of pierced cocoons, the first plot could yield 62 lbs. and the second 82 lbs. pierced cocoons besides the castor seeds.

Cost of production of cocoons on commercial scale :—Including care of eggs, rearing of the worms, cleaning and sorting of the cocoons and harvesting of leaves there were necessary 4·2 cooly days per lb. of pierced cocoons in the case of 205 lbs. produced in 21 months, 3·9 cooly days per lb. for 61·5 lbs. produced in 69 days and 3·66 cooly days per lb. for 82 lbs. produced in 79 days. In commercial rearing much unnecessary labour has got to be maintained. The experiment proved that it is not advisable to attempt rearing with paid labour on commercial scale.

Machines for cleaning pierced cocoons and spinning thread from them :—In the course of the Pusa experiment Mr. R. W. Coryton designed and patented a machine for cleaning pierced cocoons by reversing them inside out. In the machine a rod is pressed against the closed end which is forced out through the open end. The details will be found in the memoir.

The writer designed and patented a continuous spinning machine called "Pusa continuous spinning machine" for spinning thread out of the cleaned and boiled cocoons through application of treadle power, on the principle of the "flying needle" in power spinning. The machines manufactured by Messrs Turner Hoare & Co., Bombay, proved costly. Cheaper models made locally with cheap materials have been adopted in many places to spin long fibres. The details will be found in the memoir. Patent though obtained has not been maintained for any of these machines.

* *Boiling and degumming cocoons* :—Experiments were carried out to find out a substitute for the ash water used in Assam. As a result crystal soda 25% or monohydrated soda 12% of the weight of clean cocoons has been found to be a good saponifying agent. Then if the boiled cocoons are again boiled for a few minutes in hot soap solution with soap about 10% of the weight of cocoons a very clean and white thread can be obtained.

Bleaching and dyeing of the thread or cloth:—Details are given in the memoir.

Outturn of thread from cocoons :—The best clean cocoons yielded handspun thread at the rate of about 10 to 12 oz. per lb. of cocoons, about 10 oz. being the average. Spun *eri* yarn was prepared in Chhoi Silk Mills, Bombay and was almost indistinguishable from spun mulberry silk. Unfortunately no record of outturn was kept. *

Attempts at commercial rearing :—A few planters in Bihar made attempts at rearing the worm with paid labour under guidance from Pusa but without success.

Efforts at introducing Eri rearing in other provinces of India :—Along with the experiments at Pusa the Imperial Entomologist undertook efforts at introducing and establishing *eri* rearing on a cottage scale practically all over India. As an essential factor in successful rearing is renewal of stock from distant places, arrangements were made for seed supply from different places. The efforts were not crowned with success.

As castor is grown as a field crop in many places the cultivators could rear small lots of cocoons. The difficulty was collecting these small lots and paying for them. It was not remunerative to do so at the prices the cocoons fetched. Spinning of the cocoons into thread is not easily taken up by cultivators' families in new places. It requires especial efforts and time to create a taste and inclination for spinning. Rearing therefore in new areas came to a stop.

B. *Rearing at Bhagalpur* :—The work carried on at Pusa was continued and was later on transferred to the new Government Silk Institute, Bhagalpur, where it has been continued by Rai Sahib M. N. De, who has been its Principal from its start. In addition to Bhagalpur another egg-producing centre has been established at Ranchi, and from both these centres eggs are supplied to rearers in the province as well as outside the province. The industry is being attempted to be developed in Bihar as a small cottage one with however hardly much hope of success yet. Rai Sahib M. N. De wrote a note at the writer's request and the following figures are taken from that note.

An acre of castor well-cultivated yields about 70 maunds (5,740 lbs.) leaves and 10 maunds (820 lbs. seed).

One hundred female moths lay one oz. eggs in the first and second nights numbering about 16,000.

Worms hatching out of one oz. of eggs (1) eat about 10 maunds leaf and (2) produce about 36·5 seers (about 74 lbs.) green cocoons which weigh about 300 to seer (i.e. 2 lbs.) thus numbering about 11,000.

Out of 1 seer (2 lbs.) green cocoons the chrysalids weigh 13½ *chattaks* (27 oz.) and silk 2½ *chattaks* (5 oz.). The proportion of green cocoons to the silky substance by the weight is 6·4 to 1.

About 2,500 empty cocoons go to one seer.

From one seer (2 lbs.) of best pierced cocoons 10 *chattaks* (20 oz.) hand-spun thread is obtained.

Madras (see pp. 577-8, Indian Tariff Board, Written Evidence, I, 1940) :—In 1930 a practical *eri* worm rearer and his wife who knew how to spin thread out of *eri* cocoons were taken from Bengal and made to do rearing and spinning in Chittoor District with climatic conditions considered favourable for silkworms under the supervision of an influential person connected with a local weaving establishment. Several rearings were conducted in two villages about 18 miles apart for over a period of six months. Several men and women were trained in spinning and sent out to places where agriculturists had taken to rearing successfully. Though rearing succeeded, spinning did not keep pace with cocoon production as the agriculturists did not take to spinning with the same enthusiasm as to rearing. Cocoons therefore accumulated with the rearers who were anxious to dispose of them. Samples of cocoons were sent to the Imperial Institute, London, American Silk Association, Indian Trade Commissioner, Hamburg, British Commercial Counsellor, Rome and others, with hardly any sympathetic reply from any one of them. Attempts at selling cocoons in Assam were not successful. The thread spun with hand locally did not find a market. Hand-spun thread obtained from Bhagalpur Silk Institute was woven locally but the cloth did not find favour with the merchants. At the suggestion of the Imperial Institute, London, 150 lbs. cocoons (evidently dried and pierced but not mentioned as such) were sent to Messrs. Lister & Co., Bradford, who returned 40 lbs. 14 ozs. of spun yarn and 13 lbs. 15 ozs. of noil yarn or a total of 55 lbs. If 20 per cent is deducted on account of pupal shells and larval skins remaining in pierced cocoons about 120 lbs. silken shells yielded 55 lbs. yarn or about 47 per cent of their weight. Messrs. Greenwood and Batley gave out of 18 lbs. pierced cocoons 3 lbs. 2 oz. spun yarn and 4 lbs. 4 oz. of noil yarn or a total 7 lbs. 6 oz. or about 51 per cent of the weight of silken shells. Messrs. Lister & Co. quoted 9d. per pound of pierced cocoons, a totally uneconomic proposition. Cloths woven with the spun yarn commanded a ready sale. On account of variation in the proportion of spun yarn out of the cocoons it appears a choice has to be made as to machinery.

The higher the proportion of spun yarn the better. This experiment arrived at the following data :—

Outturn of leaves from one acre, if plucked from the beginning	6,150 lbs. (75 mds. of 82 lbs. each)
If plucked after fruits are fairly set	4,500 lbs. (55 mds.)
Leaves available for three months only in the year allowing of only three rearings —	
Leaves available for each rearing	1,500 lbs.
Cocoons (green) at 1 lb. for 10 lbs. leaves	150 lbs.
Pierced cocoons at 1 lb. from 7 lbs. green	$21\frac{3}{7}$ lbs.
No. of dry pierced cocoons in 1 lb.	1,500 (evidently cocoons were of medium size)
Approximate No. of eggs in 1 oz.	17,000
No. of worms usually hatching from 1 oz. eggs	16,000
Quantity of pierced cocoons from 1 oz. eggs	$10\frac{2}{3}$ lbs. (possible only if all rearings are quite successful)
Total quantity of pierced cocoons in 3 rearings	64 lbs.
At 8 annas per lb. of pierced cocoons the income is ...	Rs. 32
Cost of production (including price of eggs at 12 as. per oz., appliances, extra labour, kerosene oil etc. and excluding cost of castor cultivation)	Rs. 19
Profit per acre	Rs. 13

In Madras Presidency the acreage under castor is estimated between 250,000 and 300,000. It was thought that if the cocoons could be utilised by the establishment of Spun Silk Mills the agriculturists could do rearing bringing in some cash. *Eri*-rearing has been continued on experimental scale. It is however complained that the prices offered for cocoons by the Spun Silk Mills, Mysore, is not attractive to the rearers.

The United Provinces :—An officer was placed on special duty in 1911 at Shahjahanpur who established a farm to demonstrate how to grow *eri* at a profit on a large scale. The venture involved loss and the conclusion was that *eri*-rearing could be done only as a cottage industry (*Report on Enquiry into the Silk Industry in India*—Lefroy Vol. I, p. 132).

Baroda and Rajputana States :—During recent years demonstrators were appointed in these States to try to introduce and establish *eri* worm rearing and *eri* cocoon spinning but without success.

94. Important aspects of the *eri* silk Industry.

From the nature of the industry in its home where it has existed from time immemorial and from the results of various attempts at introducing it in different places in India described above, the following aspects of the industry become clear and have to be remembered in future attempts, viz. :—

1. Rearing of the worm is essentially a cottage industry and production of cocoons should never be attempted on commercial scale with paid labour.

2. Cocoon production as an industry allowing of export of cocoons and cloth outside the area of production exists only in sparsely cultivated poor areas of Assam and even in such areas although some individual rearings produce as much as 40 lbs. cocoons in a year the average production per family does not exceed about 10 lbs. and in some places it is smaller still. In areas which are more advanced economically through agriculture and other occupations although the tradition of rearing persists, cocoons are reared only for utilisation in the family. This emphasises the cottage nature of the industry.

3. In the western districts of Bengal it has existed purely as a small-scale cottage industry and it is in the hands of poor old women who grow a little castor near their home, rear small lots of worms, spin the cocoons themselves and sell the resultant thread. Some families do the rearing and spinning with the object of getting cloth for their own use.

4. In other areas where the industry shows signs of promise it is on lines that some one purchases cocoons, gets thread spun on payment or purchases thread and gets cloth woven. When facilities are created for rearing, more cocoons are produced than can be spun by the rearers themselves and it is an incentive to rearing if a ready sale is found for cocoons. In villages some poor and old women or men are content to do spinning and earn something. Therefore cocoons can be got spun on payment of wages.

5. The Assam *eri* cloth which has a reputation for softness of wear and durability is an attractive piece of cream-coloured soft stuff. The cocoons require to be properly treated, the thread has to be properly spun and the woven fabric properly finished. The writer has seen hand spun and woven *eri* cloth which looked hardly better than a dirty-coloured coarse gunny cloth. It might improve after several washings but it would hardly find favour with any merchants except those who know *eri* and would undertake the trouble to get it washed and properly finished.

(a) As regards treatment of cocoons the method advocated in India so far of allowing the moths to emerge has got to be changed. When moths are allowed to emerge they dirty the cocoons with their excreta and the brittle pupal cases remaining in the pierced cocoons present a difficult problem. When the cocoons are boiled and spun bits of these cases get intertwisted in the thread which can never be cleaned and the innermost part of the cocoon shell may have to be rejected on account of the difficulty of getting rid of the broken bits of the pupa cases. In Assam when the cocoons cannot be cleaned by shaking out the live pupa and the last skin of the worms the pupa is killed inside by exposure of the cocoons to the sun. This is certainly a better method though followed empirically than allowing the moths to emerge. The dry pupa is easy to be removed from the boiled cocoons. The best course is to widen the open end of the cocoons by slitting it to some extent with a sharp knife, razor or razor blade and shake out the pupa and the last skin of the worm. The slitting does not interfere with the spinning quality of the cocoon. The pupa when available in quantity may probably be used for extraction of fat. Even pierced cocoons can be cleaned of the insect remains in this manner. It is however easier to shake out the pupa. Cleaning of cocoons in this manner should be introduced as a part and routine process of rearing. The rearers should market only cleaned cocoons.

(b) Boiling for hand spinning is best done with a weak alkali solution so as not to weaken the strength of the fibres. The reputation of the cloth for durability is to a great extent due to this. If the cocoons are boiled in strong alkali solution the fibres lose strength and can be carded out and spun on the common spinning wheel (*charkha*) like cotton. This however is at the expense of strength and durability. Boiling is best done with soda solution as described in Pusa experiments above in order to have a clean stuff to spin from and secure a clean thread.

(c) As regards spinning of thread much of what has earned the reputation of the cloth for softness is lost if thread is hard-twisted. Spinning with the hand spindle (*taku*) prevents hard-twists being given to the thread. When spinning is done on hand machine care has to be taken against hard-twists.

(d) The spinner should have before him while spinning the thread, a sample about 6 inches long of the spun thread to indicate the thickness desired and this thickness should as far as possible be maintained in order to ensure uniformity of texture of the future cloth.

The above remarks about boiling and spinning are not applicable when cocoons are turned into spun yarn in Spun Silk Mills. The spun yarn is a product different in look from hand spun Assam *eri* and on account of the uniformity and good look cloth from spun yarn sells on its own merits. The Spun Silk Mill may follow its own methods.

6. In all the trials so far made in India castor has been the only food used for the worms. This plant especially when grown on plantation scale has the risk of suffering from several insect pests out of which two are frequently bad and upset the programme of rearing. One is the Castor Mealywing (*Aleurodes ricini*) which looks like small oval scales and literally covers the entire under-surfaces of leaves, causing them to turn yellow and drop off. Badly infested leaves even though still green are unfit to be used as food for the worms. The second is the Castor Semilooper caterpillar (*Achaea janata*) which occurs in swarms and eat away the leaves, literally stripping the plants bare. These insect pests add to the precariousness of the *eri*-rearing industry. Therefore it is worth while trying the other food plant used in Assam viz. *keseru* (*Heteropanax fragrans*) which is a perennial tree living upto an indefinite age.

7. The worms like a fairly hot humid climate and do not thrive in dry heat and cold unless the cold is mild. Therefore it is a mistake to try to rear them throughout the year. If rearing is done only during the suitable season much of the precariousness of the rearing may be avoided. Under suitable climatic conditions and with food available the rearing is generally successful. Suitable temperatures are mentioned above under the Pusa experiments. In other seasons the stock has to be maintained or eggs arranged for from elsewhere to be reared in the proper season. As a matter of fact exchange of seed cocoons or eggs is necessary between distant places to ensure success in rearing.

95. How the industry can be established.

The *eri* silk industry is possible to be established and carried on under any of the following conditions :—

I. As a small-scale cottage industry in all the three stages of cocoon rearing, spinning and weaving by the rearers growing a little castor or *keseru* in their homestead lands, or making use of the leaves of castor cultivated for seed, rearing the worms for cocoons which are spun into yarn and the yarn woven into cloth by the rearers themselves for their own use.

II. As a semi-cottage industry in which (a) cocoons are reared as in I and (b) a capitalist or an agency set up by Government or State buys up either all the cocoons or surplus cocoons disposed of by rearers, arranges for their treatment and boiling, distributes the boiled stuff to be spun by spinning families or women during their spare time in the midst of their household work, collects the spun yarn on payment of wages for spinning and then gets fabrics woven according to design on hand-looms. Dyeing of the fabric or yarn may be done to produce new designs and fashions. The woven fabric should be washed and finished before marketing. Where it is intended to establish *eri* silk industry this process in its entirety should be arranged for. In the western districts of Bengal poor old women in villages rear worms and spin the yarn which is sold. This does not afford scope for development, improvement and expansion and the hand-spun yarn produced is generally of a poor quality.

III. Successful establishment of the industry under II is expected to lead to further development in two ways viz. :—

A. Cocoons available in bulk may be utilised in Spun Silk Mills established in the country for production of spun and noil yarns. Such yarns themselves as well as fabrics woven with them in standardised forms are expected to find markets both at home and abroad.

B. Cocoons if made available in bulk will find an export market, the two essential conditions being that they must be clean and they must be available in bulk. In 1929 while the writer was visiting the Silk Association of America one manufacturer there offered to advance money if he could be guaranteed supply of 100,000 lbs. clean cocoons annually.

96. Lines on which research is necessary on *eri* silk.

1. There are many varieties of castor. It is necessary to collect and grow them at one place in order to determine the following points and make selection of the most suitable varieties.

(a) Growth.

(b) Yield of leaves.

(c) Effect on them of the soil and seasons.

(d) Food value of the leaf for the worm.

(e) Yield of seed.

2. *Keseru* (*Heteropanax fragrans*) should be tried. Details about it has been given above under food plants.

3. The following work has to be done on the worm :—

(a) Effect of feeding the worm with the leaves having different food value. This will help selection of the castor varieties suitable for the worm. Similar trials will also bring out the merits and demerits of castor and *keseru* as food for the worm.

(b) Diseases of the worm in relation to climate and food.

(c) Study of the worm in order to have the best cocoons.

PART IX.

MUGA SILK.

97. The industry in Assam.

MUGA is the specific name of a silk, golden yellow in colour and produced by an insect known to science as *Antherea assama* the life history of which is illustrated in Fig. 4 and a short general description given in section 2. The word 'muga' is also used to describe a particular type of cocoon produced by a variety of the tasar worm and the silk obtained from such a cocoon especially when used to make fishing line described as muga should not be confused with muga silk of Assam. The natural colour of the muga silk is permanent and therefore this silk is greatly valued for use in embroidery and artistic weaving and in borders of *saris* as a substitute for gold thread. Raw muga silk is in demand to some extent in different parts of India on this account. Assam valley is the only place where this worm occurs and is reared and is considered sacred by the local people there being no religious scruple to its rearing by any caste. This points to the local origin of the insect which is also supposed to exist here in a wild state. The worm is however mainly reared by the non-Aryan castes and tribes viz. the Ahoms of upper Assam, the Lahungs of Nawgong and the Garos, Rabhas and Kacharis of south Kamrup, though rearing is carried out in all districts of the Assam valley on a smaller scale.

Life of the worm and cocoon crops :—The muga worm is multivoltine and is found practically throughout the year, but only five crops of cocoons are reared in different seasons. These crops are :—

(1) *Katia* or autumn crop gathered during October and November;

(2) *Jarua* or winter crop in which the worms remain on the trees for about one-and-a-half to nearly two-and-a-half months according to the intensity of cold in different places and cocoons are obtained in spring in February-March ;

(3) *Jethua* or hot weather crop which ripens in May-June ;

(4) *Aherua* or early rains crop in July ; and

(5) *Bhadia* or late rains crop gathered in August-September.

The *katia* or autumn crop is the most important and furnishes the bulk of cocoons for reeling and these cocoons too are of the best quality and they reel well and yield about 20 to 25 tolas (8 to 10 ozs.) of raw silk and 10 to 15 tolas (4 to 6 ozs.) of wastes per *khon* (i.e. thousand) of cocoons. The *jarua* crop is the least important and is reared only for seed. The cocoons are of the poorest quality yielding about 4 to 6 oz. of raw silk per *khon.*

The *jethua* crop is important in upper Assam, the heat of the lower districts proving trying for the worm in this season.

The *aherua* crop also is important in upper Assam but unimportant in other places being reared only for seed.

The *bhadia* crop is important for the reason that it supplies the seed cocoons for the important *katia* crop.

The cocoons produced in the rainy season in *aherua* and *bhadia* crops are difficult to reel and the raw silk is of poor quality, the yield of raw silk from them being poor, about 6 ozs. per *khon.*

The life cycle of the worm according to Stack occupies the number of days shown below :—

	Minimum days in warm weather.		Maximum days in cold weather.	
Egg	7		10	
As feeding worm	26		40	
Spinning period	4		7	
Pupa	14		21	
As moth	3	Total 54	3	Total 81

The period in cold weather in upper Assam takes about 30 days more according to Basu.

Two varieties of the worm are recognised by the rearers, the difference however being only in the size of the worm and the cocoon. The smaller worm is considered hardier and therefore preferred. A third variety larger than either of these two is also believed to exist but it is more delicate and unable to retain its hold on the tree.

Food plants :—The two plants on which the worm is commonly reared are :—

(1) The *sum* (*Machilus odoratissima*) almost exclusively used in upper Assam and

(2) The *hualu*, called *haonla* in lower Assam (*Tetranthera monopetala*) generally used in lower Assam.

Both these trees are cultivated and also occur wild, the *sum* in upper Assam in large plantations in the forest and similarly *hualu* in lower Assam but in a more scattered form in the forest and also in waste lands among villages.

The worm also feeds on the leaves of the following plants which are however not used for rearing except for special reasons as indicated below but that, too, on a very small scale.

(3) The *digloti* (*Tetranthera glauca*).

(4) The *patihonda* (*Cinnamonum obtusifolium*).

(5) The *bomrati* (*Symplocos grandiflora*).

(6) The *champa* (*Michelia oblonga*).

(7) The *mezankuri*, also called *adakuri* (*Litsea citrata*).

The first three of the above are used only when they occur in a *sum* plantation but never by themselves. The last named two are used for getting two special forms of silk viz. *champapatiya* and *mezankuri* muga as distinguished from the common or *sumpatiya* muga reared on *sum* and *hualu* trees. The production of *champapatiya* and *mezankuri* muga is however extremely small and not important.

The seeds of *sum* and *hualu* are usually scattered by birds and seedlings grow in waste lands and embankments. *Sum* seedlings are frequently transplanted but not the *hualu* ones which are taken care of and allowed to grow *in situ*. *Sum* therefore frequently occurs in groves in which the trees are planted about 12 to 18 feet apart. Groves as well as scattered seedlings are protected against cattle for about two or three years. The plants are considered to be fit for use when they are about 3 to 5 years old. Newly hatched worms are placed on young trees with sufficient leaves to last till the worms complete their third age when they can be transferred without risk to new trees. *Sum* trees are said to live to an indefinite age. As no pruning is practised old trees when grown tall and liable to be shaken too much by wind and storm or when overgrown with moss, etc. which harbour ants, become unfit for use. *Hualu* has a soft wood which is bored by ants and the trees become unfit for use after about 15 to 20 years as they harbour too many ants. The trees are generally used for rearing the worm only once in the year.

Seed production and supply :—A limited small tract of hilly and jungle country lying near the southern junction of the Kamrup and Goalpara Districts and comprising the mouzas of Luki, Bongaon and Boko of the former and a part of Parganah Habraghat of the latter district, has been observed to be the only place where the insect can be reared throughout the year without deterioration and which therefore forms the primary source from which muga seed is obtained for being reared all over Assam. Rearers from both upper and lower Assam either go to this tract and get seed direct or procure seed from local rearers who have obtained seed from this tract and raised one or two broods for sale as seed. The latter method is more common than the former.

In upper Assam the worm deteriorates quickly becoming more and more diseased in successive generations and at the most three or four generations can be reared from the same stock and generally the rearers do not raise more than one or two generations.

In lower Assam deterioration is slightly slower and three to six generations may be reared. Seed is often taken from lower to upper Assam.

The rearers naturally are very particular about the quality of the seed cocoons. They frequently make long journeys, carefully observe the worms under rearing to see that the brood is of uniform growth, strong and healthy and free from disease. They wait till the worms complete the cocoons. The worms in a brood do not ripen together and frequently take five or six days and sometimes as many as 12 days. More males occur in the worms which ripen early and more females in those which ripen late. Therefore early and late cocoons are rejected and seed cocoons are taken from those which spin about the middle of the ripening period when the largest number in the brood form cocoons and males and females occur in about equal numbers. Seed cocoons usually sell at double the price of reeling cocoons.

Method of getting eggs from seed cocoons :—The rearers usually purchase seed cocoons and arrange to get eggs from the moths emerging from them. The seed cocoons are kept in a bamboo basket spread out thinly and the basket hung up out of the reach of rats, and in winter near the kitchen fire to quicken emergence. Moths usually emerge in the evening and pair. On the following morning the paired moths are taken out and the female tied on the *khorika*. The *khorika* is a roll of fine thatching grass, grass from an old thatch blackened by smoke being preferred from a notion that such grass promotes egg-laying. It is about the thickness of a finger and may be about an inch in diameter, is about 9 to 18 inches long and is provided with a hook at one end. A cotton string is tied round the base of the right hind wing of the moth and its end secured on the *khorika* leaving a length sufficient to enable the moth to move about while laying eggs on the *khorika*. Usually one pair of moths is placed on a *khorika* but in some places as many as four may be tied to one *khorika*. The *khorikas* bearing the moths are hooked on a string stretched across a room. From the same lot of seed cocoons usually moths emerge in the course of three days. Moths emerging after the third day are rejected. Each day's moths are kept separate. Pairing continues for about 24 hours and then the males fly away and the females commence laying eggs soon after and continue to do so for several days. Eggs laid on the first three days are taken for rearing and the female moths are removed from the *khorikas* on the morning of the fourth day after emergence. The *khorikas* with the eggs adhering to them are taken down and kept hung on strings stretched across the mouth of a round cylindrical bamboo or cane mat case as a protection against rats and mice and covered with a piece of cloth. The case may be kept near the kitchen fire in winter in order to quicken hatching. When hatching is expected the *khorikas* are examined daily and as soon as hatching has begun they are placed on rearing trees. Surplus *khorikas*, if any, are sold, the price being usually double that of seed cocoons.

Rearing of the worms :—When moths begin to emerge from the seed cocoons the *sum* or *hualu* trees on which the worms will be fed are got ready. All jungle below the trees is cut down and the ground cleared so as to facilitate picking of any worms which fall off the trees. The trees themselves are cleared of dead wood and parasitic growths on them and ants nesting on them are killed by fire or hot water and their nests removed. Molasses, fish entrails, flesh and other baits are placed on the trees to attract ants from the higher parts of the trees and a bandage of twisted straw is fixed round the trunk at a height of about four feet from the ground and sand or ashes are placed over it in order to prevent ants getting up on the trees from below.

The *khorikas* with newly-hatched worms are hooked on the branches with hand or with the help of a pole. Eggs falling off *khorikas* are placed in a small basket which is tied to a branch. The young worms soon crawl up to the leaves on which they begin feeding. It takes three days for the eggs on the *khorikas* to hatch and then *khorikas* are removed. As already indicated *khorikas* are first placed on young trees with sufficient foliage to last till the worms pass through the third moult. Then the worms are transferred to other trees. Success in rearing depends to a great extent on a judgment born of experience as to how many worms to be placed on a tree in order to

ensure sufficient supply of leaf of proper quality and at the same time prevent overcrowding. In a plantation having about 30 good-sized trees 200 to 300 *khorikas* with eggs of single moths may be used yielding about 12 *khons* of cocoons. Rearing is commenced on about six trees and the others are used gradually.

When the leaves on the trees are exhausted the worms descend along the trunk in search of fresh food. The straw bandage is now removed and one of plantain or pineapple leaves is put on. The worms being unable to crawl over the smooth surfaces of these leaves gather above the bandage and are picked with hand and transferred to the trunk of a fresh tree along which they crawl up or placed in a tray which is hung on the tree. Worms in different stages of growth are placed on different trees. At the time of moulting the worm rests for about 36 hours. In feeding periods they eat all day and night in summer, resting only during mid-day when the sun is too hot. In winter they rest at night and do not eat until the sun warms up the atmosphere. In the fifth age after the fourth moult the worm develops a voracious appetite and grows rapidly. When it is full-fed it wanders about for a whole day and night and then sits motionless for a few hours after which a semi-liquid excreta is voided and it begins to descend down the trunk in search of a place where to spin the cocoon. When ripe the worm is of a bright translucent colour and makes a rustling sound when held near the ear and rubbed with fingers. The ripe worms commence to descend at nightfall and continue to do so for about three hours. They gather above the plantain or pineapple leaf bandage, are picked with the hand and placed on a tray and carried home where a *jali* is provided for spinning cocoons in. A *jali* is a bundle of twigs of mango, jak, etc. having the leaves on them in dried condition and tied loosely so as to afford interspaces and in a manner allowing of its being stood on one end on a tray. The ripe worms are placed on the tray and they crawl into the *jali* and spin cocoons. When sufficient worms have entered a *jali* it is suspended from the roof of a house. About 400 to 600 worms are placed in one *jali*. Completion of the cocoon and pupation takes about four to seven days according to temperature prevailing at the time. Worms intended to produce seed cocoons are made to spin separately. The cocoons are picked off before the moths are due to emerge.

Precarious nature of rearing :—The worms left on the trees in open air are preyed upon by many enemies such as (1) birds among which crows, kites, wandering pies. owls and a little bird like the house sparrow are very injurious, (2) bats, (3) insects, among which ants, the common red wasp, hornets, an ichneumon fly and the rice bug are mentioned, (4) monkeys and jackals which are said to destroy ripe worms, (5) besides these enemies the muga worm is also liable to be attacked by the parasitic silkworm fly, *Tricolyga bombycis*, (see section 50) but fortunately not to the extent observed in the case of the mulberry or *eri* worm.

Constant watch has to be maintained by the rearer against the enemies from the day the *khorikas* are placed on the trees till the ripe worms are gathered. Bows and pellets are used against birds, wasps and hornets are beaten to death and in order to scare away birds and bats, clappers of split bamboo or empty kerosene tins tied to poles are sounded by pulling a string. High winds, hail storm, continuous heavy rain, spells of dry heat and cold are sources of danger to the worms under rearing.

The muga worms have been observed to suffer badly from flacherie disease which sometimes carries off the entire brood under rearing and occurs in the worst form in the last two ages of the worm. Grasserie also occurs rather badly with the characteristic symptoms. It would be supposed that the worm feeding at will in open air on trees should be free from these diseases. This is however not the case and it presents a problem for investigation. Pebrine has also been found in the worm.

Treatment of cocoons :—Cocoons intended for reeling are stifled over a fire. Flyblown cocoons are stifled as soon as detected so that they may not be spoilt by the maggots piercing through them. Exposure to the sun does not kill the insects inside. This is why artificial heat is used in the following manner. A bamboo platform about four feet from the ground is covered with a thick layer of green plantain leaves. The

cocoons are spread on the leaves and covered with a second layer of leaves in a way to exclude air. A fire made below the platform is maintained for two or three hours and this process may have to be repeated. The stifled cocoons are dried in the sun for several days and then stored until wanted for reeling.

The bulk of the cocoons are reeled by the rearers themselves or their neighbours for their own use. Kacharis, Rabhas and Garos however do no reeling and sell their cocoons in weekly *hats*. The cocoons ultimately find their way to Palasbari and its neighbourhood where muga reeling is an industry of some importance. The resultant thread is either woven or sold at Palasbari and Gouhati.

Reeling of the cocoons :—The cocoons are boiled in alkaline water or *khar* prepared as described for *eri* cocoons (section 91) but sometimes a slimy substance is added to the boiling liquor. The substances used ordinarily for this purpose are the core of the *chalta* fruit (*Dillenia indica*), *simul* (*Bombax malabaricum*) bark and leaves of *ageru* (*Sida* sp.) and *lafa sag* (*Malva arvensis*).

At the time of reeling the treated cocoons are placed in the basin of the primitive reeling appliances in use for reeling mulberry cocoons. The water in the basin is cold in the case of good cocoons or slightly heated in the case of inferior ones. Each cocoon is taken up in hand and the outer floss removed until the continuous filament is obtained. Filaments of several cocoons are passed together to form the thread.

Spinning of pierced cocoons and waste obtained in reeling :—Spinning is done in the same way as *eri* cocoons described in section 91 and the resultant hand-spun thread is known as *era*.

98. Lines on which research seems necessary on *muga* silk.

(1) Investigation to find out if there is more than one variety of muga worm.

(2) Investigation on the relative values of the known food plants of the worm.

(3) Experiments at growing the food plants, *sum* and *hualu* and others if found suitable, in regular plantations with pollarding and pruning so as to have low trees with numerous branches and large foliage in the same way as oak is grown in China and Japan for rearing the Chinese tasar and Japanese muga worms. Such plantations are also easy to watch.

(4) Occurrence of flacherie and grasserie diseases in the worm is evidently connected with the quality of the leaf on which it feeds. The food value of the leaves, the effect of abundance or deficiency of any of their constituents, changes in the leaves brought about by manures and cognate matters are subjects for investigation in this connection.

(5) When the muga worm is fed with the leaves of *mezankuri* and *champa* it produces a silk with creamy white colour unlike the common golden coloured muga produced by feeding the worms on *sum* and *hualu* leaves and then known as *sumpatya* muga. The former fetches a fancy price. The age of the trees is said to have the greatest effect. Two year old trees produce the best silk and this silk can be obtained for only three years. Leaves of trees in the fifth year or older are said to produce silk hardly distinguishable from the common *sumpatiya* muga. This is a matter for investigation in connection with the food value of leaves.

(6) It is worth while trying the food plants in other areas. Climatic conditions suitable for the worm may be found in many places. After the food plants are grown rearing of the worm can be tried.

(7) The colour of the silk is in its favour and enables it to command a high price. Experiments aiming at making rearing easy and increasing production are desirable.

(8) Reeling processes of muga cocoons are capable of improvement and form a subject for experiment. Unlike the filaments of mulberry silk cocoons muga filaments are devoid of natural gum when issuing out of reeling basins. A process of giving a twist to the thread as it is reeled has to be developed. Mr. B. B. Roy, Officer in-charge, Bengal Rawsilk Conditioning House, is experimenting on this line.

PART X.

TASAR SILK.

[*This part is based mainly on information supplied by Rai Sahib M. N. De, Principal, Silk Institute, Bhagalpur, Bihar.*]

TASAR is variously written as Tussur, Tusser, Tussore, Tesser, Tussah, Tusseh and Tusha.

99. Cocoon production.

The tasar silkworm has been illustrated in Fig. 3, and a short general account of it has been given in section 2. Its habitat is probably Singhbhum in Chhotanagpur within the province of Bihar. It is found in almost all parts of India sporadically but intensively in Chhotanagpur in Bihar and to some extent in parts of Orissa, the Central Provinces, Bengal and the United Provinces adjoining or near about Chhotanagpur.

Varieties :—There are three different varieties of the worm, one being univoltine, another bivoltine and a third trivoltine. All are found in wild state in the same area and have therefore been mixed up. They are distinguished by the cocoons produced which are naturally of different sizes, shapes and colour. Some are compact and some flimsy, the peduncles of some are longer than those of others and the colour of some is fawn and of others drab, whitish or yellowish and may be anything varying from grey to deep brown. In nature moths emerge from the cocoons practically throughout the year, generally after a rainfall between April and October and a few between November and March. Moths emerging from different types of cocoons mate without any choice. The varieties and forms indicated by the cocoons are known by different names in different places such as Mudia or Mugai, Daba, Jatadaba, Sarhian, Bogai, Ampatia, Langa, Bankura, Pathjhara, Barsati, Narya, or Larya, Juddui or Jarhan, Barbhanga, Armori, Nagpuria or Raili. Some of the local forms are viewed as varieties while others are accidentals due to environment, semi-domestication, climate, food plants, hybridisation and mongrelisation between themselves. Mudia or Mugai, Bankura, Pathjhara, Barbhanga, Sarhian, Daba and Jatadaba cocoons are the best and Ampatia and Jarhan cocoons are the worst.

Wild nature :—The tasar worms are more wild in nature than the muga worms and not only feed on trees at will in the open but also spin cocoons in the open on trees. The cocoons have then to be collected. Breeding takes place in nature in forests from where much of the cocoons which come into the market is collected. Even when rearing is carried out under care the wild nature of the insect is maintained. For instance moths are put outside to be fertilised by wild males. The moths can be mated under control as will be described below. The Japanese muga and Chinese tasar worms are hardly less wild but mating of moths is controlled in their cases. As a result of unchecked mongrelisation between the varieties taking place for generations many irregularities have appeared. From the eggs of the same mother cocoons of different kinds are produced, emergence of moths from the cocoons is not regular and the eggs from such moths hatch irregularly. When seed cocoons are kept out of lots reared under care more regularity is observed in the emergence of moths. Therefore some prefer to rear from their own stock instead of from wild seed cocoons although the result of rearing is less satisfactory in the former case.

Food plants :—*Asan* (*Terminalia tomentosa*), *Arjun* (*Terminalia Arjuna*) and *Sal* (*Shorea robusta*) are considered to be suitable food plants of the tasar worms which are also known to feed on leaves of *Sidha* (*Lagerstroemia parviflora*), Blackberry (*Eugenia Jambolana*), plum (*Zizyphus Jujuba*), Fig (*Ficus glomerata*), country almond (*Terminalia Catappa*), *Bahera* or *Bhaira* (*Terminalia belerica*), *Simal* (*Bombax malabaricum*), *Mahua* (*Bassia latifolia*), *Karanda* (*Carissa Carandas*), *Pipal* (*Ficus religiosa*), *Bharas* (*Lagerstroemia indica*), *Joel* (*Odina Wodier*), *Hamisabiti* (*Mitragyna parviflora*), Teak (*Tectona grandis*),

Sanai (*Crotalaria juncea*), *Patua* (*Corchorus olitorius*), *Arhar* (*cajanus indicus*), Myrabolan (*Terminalia Chebula*) and Mango (*Mangifera indica*).

Asan trees on which the worms thrive best are found abundantly everywhere in the tasar rearing area. The trees occur sporadically throughout the forests and the area covered by them is not capable of estimation. Occasionally the *asan* trees are pollarded in order to have low branches. Usually the food plants are used as they are found in the forests. In the Damin of the Santhal Parganas each rearer has to pay a tax amounting to Rs. 1-5-0 for using the trees in rearing worms. A plantation, say of *asan* can be started in the following manner.

The ground should be cultivated and levelled first. Trees should be planted at a distance of about 20 feet and they should be allowed to grow more than nine or ten feet. Seedlings six to eight feet high may be dug out with roots for transplantation in July after rainfall. Rearing should be commenced in the fourth or fifth year. If possible they should be used for rearing on alternate years. They should be pollarded on alternate years and pruned slightly every year about six weeks before the commencement of rearing. Wild trees can be used for rearing after or before pruning.

How seed cocoons are procured :—Seed cocoons are generally collected from the forest by aborigines. Cocoons from *sal* trees are considered to be the best. Singhbhum is considered to produce the best seed cocoons but many rearers go for seed cocoons to Mayurbhanj State.

The rearers of Singhbhum have begun to rear worms from seed cocoons raised by themselves and they do not go in for wild seed cocoons. The rearers of other places will make it a point to collect wild seed cocoons from distant localities which they call Bankura, Pathjhara, Mudia and Barbhanga. Seed cocoons are generally obtained from Monohorpur, Chaibassa, Chakradharpur and Chakulia in Singhbhum. Giridih in Hazaribagh is another centre for seed cocoons. Villagers generally collect cocoons from neighbouring forests. It is difficult to procure large quantities of good seed cocoons from one place. Seed cocoons some times sell for Rs. 2 per *pon* i.e. 80 cocoons whereas ordinarily their price is about Rs. 7 per 1,280 cocoons or *kahon* called *khari* in the case of tasar cocoons. Many rearers cannot start rearing for want of seed cocoons or eggs. The aborigines, Santhals, Kols, Hos, Bhils and Paharias generally travel to distant parts to purchase wild seed cocoons as the eggs from their own brood do not always give satisfactory results. They however rear from their own stock if wild seed is not available.

How eggs are got from seed cocoons :—Seed cocoons are generally kept suspended with ropes. They are protected from rats. The moths emerge at night. The male moths are let off and allowed to fly away but the females are tied by means of a thread at the end of bamboo poles which are kept outside in the evening. They are visited at night by wild males from the neighbouring forests and are thus fertilised. The aborigines believe that tasar moths do not pair in captivity which is however not correct. Some persons superstitiously avoid the mating of moths from the same lot of cocoons as between brothers and sisters. In the morning the males fly away and the fertilised females are brought home and kept in earthenware vessels and commence laying eggs in the evening. They continue laying for 2, 3 or 4 days after which they are thrown away. The eggs are scraped off and kept in fresh leaf cups for five or six days. Each moth lays about 150 to 250 eggs. Sometimes the seed cocoons are kept tied to a pole or branch of a tree. The moths come out at night. The males fly away but the females sit on the cocoons. Wild males visit the females at night and fertilise them. The fertilised moths are then kept in earthenware vessels for oviposition. Sometimes the moths are kept in leaf-cups for laying eggs.

The female moth is of a bright yellow colour, bigger than the male, while the male is much smaller with a small abdomen and is of brick red colour. They generally die on the fourth or fifth day after emergence. The unfertilised females lay comparatively smaller number of eggs which do not hatch. In Bihar the Government have started four tasar seed stations where tasar seed cocoons are collected for distribution of cellular or disease-free eggs. The moths are allowed to emerge out in a spacious room where there is sufficient air and light. Here they pair in captivity at night. In the following afternoon the

pairs are separated, the males are thrown away and each female is kept isolated in a small bamboo basket where it lays eggs in two or three nights. After two or three days the female moth is examined for pebrine spores or flacherie germs and in case of infection the eggs are rejected. In this way many moths are kept for oviposition and examination. The cellular eggs are distributed to selected rearers. Sometimes they are sent by post in perforated boxes for rearing in distant localities.

Rearing:—In summer the eggs hatch on the eighth or ninth day after oviposition but in winter they hatch on the 20th day. They are small, white, flattened and oval and change to bluish colour before hatching. Just before hatching the leaf cups with the eggs are tied or sewn on branches of the trees on which rearing is intended. The worms on hatching commence to eat leaves and quickly increase in size. They cast their skin four times after intervals of three to seven days and commence to spin cocoons in about 30 days in summer and about 60 days in winter. When full grown the worm is about four inches in length. When the leaves are exhausted on a tree the worms are transferred to other trees. The cocoon is closely woven and firmly-cemented and formed within some leaves on small twigs and it is secured by an ingenious loop fastened on the top of the twig. The cocoon is spun completely in four days. On the fifth or sixth day after commencement of spinning when many cocoons are seen to have been spun they are collected and brought home and kept in baskets. The newly-hatched worms are distributed over a number of trees and they are watched during the day. One man can keep watch over about 100 trees or more. Scare-crows and bows and pellets are used for driving away insectivorous birds. The rearers observe strict and sometimes severe austerities during the rearing out of superstitious beliefs. The average yield of cocoons from 100 full-grown trees about ten years old is about 5,000. The price of a *khari* of 1,280 cocoons varies from Rs. 2 to Rs. 8. The yield of reeled silk from a *khari* of cocoons varies from half to one seer, besides waste, which fetch about Rs. 12 to Rs. 18 and Re. 1 respectively. A piece of cloth 5 yards × 44 inches can be made from the thread of about 500 cocoons. The price of the cloth is about Rs. 5. The rearing is generally done by aborigines such as Santhals, Hos, Pahariyas, Mal Pahariyas, Kurmis, Bhunyas, Goalas, Doshads, Chamars, Kherwars, Mussalmans, etc. There are about 60,000 rearers and collectors of cocoons in Bihar. All do not rear every year. The average production per rearer is about 2½ *khari*. Some earn more than Rs. 50 per year and some do not earn a single pie when the worms die. There is no fixed income. The industry is a precarious one, as there is no sure return and the rearers drop off if any profitable occupation be forthcoming.

Diseases of tasar worms:—M. N. De examined many worms after the third moult when they began to fall off from the trees. The contents of the alimentary canal of some showed diplococci and micrococci. He could not find any pebrine, grasserie or muscardine in any of the worms though he examined about 300.

Tasar worms are rarely attacked by pebrine. They sometimes die in large numbers of grasserie after heavy rain succeeding a protracted drought. They are reported to be attacked with *maur*, *kapsi*, *hajari* (cholera), or *jhair* and bald-headedness, *meshi* or *lorka* and *angaria* (black like coal). Most of these appear to be symptoms of flacherie in some form or other. The alimentary canals of many tasar worms contain eggs and caterpillars of small moths and insects which lay eggs on the leaves eaten by them. In some cases the contents of the stomach are very hard. The faeces are so hard and big that they cannot pass through the anus and the worms die as a consequence. The juice of the alimentary canal of some shows acid reaction.

Area of production and supply of cocoons:—Bihar, the main area, produces about 3¼ lac rupees' worth of tasar cocoons annually. About 75 per cent of these cocoons are exported to Bengal and the Central Provinces and the balance is utilised in the Province of Bihar for reeling, spinning and weaving. The rearers sometimes receive advances from *mahajans* who thus receive the cocoons and sell them to weavers or export them. Merchants generally come to important markets to buy tasar cocoons. The cocoons are brought to the principal markets which are located in Singhbhum, Giridih, Amrapara,

Kathikund, Godda and other places. In Bihar reeling and spinning of cocoons is done by Gosians, Pustis, Tantis and Mussalman weavers. The women generally reel and spin the cocoons and the men weave them. Recently some aborigines who are rearers have taken to spinning but their number is small. Generally rearers neither reel nor spin the cocoons.

100. Utilisation of cocoons.

Treatment and reeling of cocoons :—About 500 cocoons are boiled in about nine seers (about two gallons) of water containing half a seer (one lb.) of ashes and half a *chattak* (two ounces) of crude soda for about an hour. The cocoons are then washed with clean watei and put in a dry cloth bag which is covered with dry ashes to absorb the water from the cocoons. The outer covering or floss from the cocoons is taken on a *natwa* (spindle) till the continuous filament is obtained and is used in the weft for weaving coarse pieces. In many places this floss is sold and not used. Usually five filaments from five cocoons are rubbed with one hand across the left thigh of the reeler who squats on the ground with out-stretched legs and slightly twisted together to make a thread which is wound upon a *natwa* or spindle twirled in the other hand. The cocoons for reeling are put in a basket or vessel containing dry ashes. Pierced cocoons are also reeled in this way, but it takes longer time to reel them and the thread produced is inferior. One woman can reel about 500 cocoons in about 14 days. Reeling can also be done on reeling machines on which mulberry cocoons are reeled. Reeling should be done slowly or lumps of tangled thread come off from the cocoon. About 36 years ago there was a filature in Murshidabad District in Bengal reeling tasar cocoons. Small wire-cages containing sufficient cocoons for a reeler used to be put in a large wire-cage which used to be lowered into a vat for cooking of the cocoons. Cocoons remained on a flat metal pan while being reeled.

The under-boiled cocoons are boiled again. The method of boiling differs in different parts. In Mirzapur they boil in crude soda solution only.

Tasar filaments in the thread are not gummed together live mulberry filaments even if croisures are given. Gummed thread can be obtained if the filaments are passed through a special gummy preparation (gum of sterculia, bark of silk cotton tree and *lafasag* of Assam). The thread in such a case improves by a glossy appearance being imparted to it.

In Bhagalpur the process of boiling is as follows :—Put 400 cocoons in an earthen jar with split bamboos arranged in the bottom in threefolds so that the cocoons may not come into contact with direct heat. Add six seers of water in the jar and cover it with a lid. Boil over slow fire for about five hours till the water is almost exhausted. When a peculiar fleshy smell comes out of the jar it should be taken off the fire and kept on some ashes. The lid should not be opened. If boiling water overflows, apply a little mustard oil with a split bamboo or palm leaf between the lid and the jar. Dry cowdung with wood should be used as fuel. Charcoal can be substituted though it does not give satisfactory results. Do not open the lid till the cocoons cool down completely.

Next day open the jar, pick out under-boiled cocoons and put them back again in the jar. Half-boiled and small ones should be kept towards the top. Add 2½ to 3 seers of water and boil for about four hours till the water is exhausted and treat the jar as before. Next morning pour out the cocoons from the jar. Do not allow flies to sit on them. Pick up the soft and well-boiled ones, put a cloth over them on a bamboo mat and slowly pour water over the cloth in order to remove stickiness from the cocoons. Turn the cocoons upside down and pour more water. This will serve the purpose of washing. If the cocoons are not sticky they need not be washed. Spread some dry ashes somewhere, cover them with a cloth over which place the cocoons which should be covered with a cloth. Keep the cocoons over the ashes for about an hour. Now keep the well-boiled ones for reeling and the hard ones in a jar which has been previously provided with *samalu* leaves. Some use *samalu* and *nim* leaves to scare away flies. With the lid on the jar should be put in the sun and at night over an oven which has been put out but still emits a little heat. Many reelable cocoons will now be found next day or day after. If after five days all the cocoons have not turned soft and reelable, put the under-cooked ones

in a jar the mouth of which is covered with a wet piece of cloth. This jar should be placed upside down over the mouth of another jar used for boiling a fresh lot of cocoons. The jar should be opened the next day when many reelable cocoons will be found.

Under-boiled cocoons which have not turned soft are washed as before and put on a pan provided with wet ashes and between two layers of cloth and heated over a slow fire when steam will come out. The heating is continued for about an hour. The cocoons are taken out, kept within two layers of dry ashes for 15 minutes and then they are found suitable for reeling.

Sometimes boiling is done for the third time with about half seer of water for about four hours, and then the cocoons are kept overnight as usual. Next day they are washed with water between two layers of cloth. Then they are kept over ashes for half an hour and some of them are found to be reelable. Sometimes well-boiled cocoons are dried and stored for being reeled leisurely.

M. N. De has obtained the best results by following the under-mentioned method :—

Take one *khari* (1,280) cocoons, cut off the peduncles and soak them in 1 per cent hydrochloric acid overnight. Take them out, knead them with one tola (about half oz.) of washing soda and put them in an earthen jar the bottom of which is perforated. Fill another earthen jar with 8 to 10 seers of water with 1½ tola (about 3/5 oz.) of washing soda. Heat this jar over a slow fire and place the jar containing the cocoons over its mouth. Steam will pass into the upper jar which should have a lid plastered and fastened with mud. The cocoons will be cooked in about 3 hours. Under-cooked cocoons, if any, should be steamed again for about half an hour or more. Reel as usual.

Stifling of cocoons :—Green cocoons are stifled in the same way as above by boiling for about an hour. They cannot be stifled by exposure to the sun like mulberry cocoons. If they are not stifled in time moths come out of them by opening a hole through one end.

101. Manufacture of *tasar* goods.

The thread at present produced is woven only on hand-looms. The fabrics produced are :—*Dhoties* (cloth worn by men), *sarees* (cloth worn by women), *chadars* (wrappers), shirtings, coatings, *bafta* (i.e. cotton weft and tasar warp) coatings and shirtings and *dudhmalai* (i.e. checks of tasar and cotton mixed) shirtings and coatings. Bihar produces about two lac rupees worth of tasar goods annually.

The weavers do not make long warps with tasar thread as they experience considerable difficulty in sizing longer warps than 10 to 15 yards. For every 10 yards of about 2,800 warp threads the following are used as sizing materials in Bhagalpur :—Rice ½ seer (1 lb.), thick juice of boiled rice 6 seers (12 lbs.), mustard oil 1 *chattak* (2 oz.), fat 1 *chattak* (2 oz.) and water about 5 seers (1 gallon).

They generally use untwisted thread in the warp and weft. The warp prepared unsized is stretched out and sized with a brush by sprinkling sizing mixtures over the warp. The entire warp is brushed fairly well and dried. Weaving is done on both throw-shuttle and fly-shuttle looms.

At Mauda (Singhbhum) and other places twisted and untwisted reeled tasar is used in the warp. The weavers prepare a thin gruel with *aloa* (sun dried) rice. The reeled thread is soaked in it for half an hour. The surplus size is squeezed out and the yarn is allowed to dry and then kept in the fold of a wet cloth. The yarn is then wound on the bobbins which are used in warping. Bamboo reed and throw-shuttle looms are used.

102. *Tasar* waste.

As in the case of mulberry silk flimsy unreelable cocoons, outer floss from cocoons, pierced cocoons and the peduncles of cocoons form the waste. In the case of tasar, however, an inferior raw silk is prepared in some places from the outer floss as explained below and the superior pierced cocoons are also utilised for the same purpose. The thread is non-uniform as there are many knots and knobs. Inferior pierced cocoons, flimsy cocoons

which are unreelable and the unreelable parts of cocoons locally known as *guddar* are spun with hand. Formerly they used to be sold for annas three per seer and exported to Europe. Their export has stopped from the time of the last great war. Almost all kinds of tasar waste are now spun with hand into thick or thin threads. This hand-spun tasar thread is known as *kete.*

The rearers were ignorant of spinning or reeling and used to sell their pierced cocoons to local *banias* who sold them to merchants. Now some rearers have commenced to spin their cocoons. Tasar waste is being imported now-a-days to Bhagalpur from Sambalpur and other places for this purpose. From one seer (2 lbs.) of superior waste 14 *chattaks* (28 ozs.) of thin spun thread is obtained but from one seer (2 lbs.) of inferior wastes about 9 *chattaks* (18 ozs.). From 80 flimsy cocoons about one *chattak* (2 oz.) of spun thread is obtained.

Tasar waste is called *latha* when it is cut in about 18 inch lengths. There are different qualities of *latha.* They are sold from Rs. 15 to Rs. 45 per maund (82 lbs.). It does not pay to spin the worst qualities which are generally used in spinning mills.

The peduncles of cocoons are called *boks.* They are boiled in water for three times and washed with water. Then they are placed in the sun for drying. When they have about 15 per cent moisture they are beaten with sticks and made into floss silk which is used for padding quilts and beddings. The price of one seer (2lbs.) of peduncles is annas four and it is sufficient for one quilt. They are sometimes spun into thick yarn which is woven into *chadars* and loin cloths.

103. *Kete* (hand-spun *tasar* thread).

Kete is produced at Bhagalpur, Katoria, Bhagaya, Gaya, Biharshariff, Raghunathpur, Singhpara, Mauda and Chaibassa in Bihar and Bishnupur, Bankura, Dainhat in Bengal and Sambalpur, Maurbhanj State, Orissa States in Orissa and other places.

Methods and organisation of Kete spinning :—One seer (2 lbs.) of pierced and filmsy unreelable cocoons is boiled in 10 seers (2 gallons) of water containing 2 *chattaks* (4 ozs.) of washing soda for about three hours. Two *chattaks* (4 ozs.) of *sajimati* (fuller's earth) or 4 *chattaks* (8 ozs.) of ashes of *asan,* plantain, *arjun* or straw can be used instead of washing soda. The cocoons can be made suitable for spinning even if no alkali is added but then they should be boiled in pure water for about four to five hours. They are then washed in clean water and kept in a dry cloth bag which is covered with dry ashes to absorb the water.

The ghicha or drawn thread :—The outer covering of floss from each cocoon is drawn on a *natwa* (bamboo reel) and is used in the weft for preparing dark and coarse *chadars.* In many places this floss is simply kept aside and sold as *guddar* or waste tasar. A bunch of about 100 threads from each cocoon is drawn out and wound on a *natwa* or spindle after being twisted by the right hand. The circumference of the skein is about 16 inches and about 1 *chattak* (2 ozs.) of thread is wound on each skein. No machine or instrument is required for preparing this thread. The twist given when it is being drawn is slight. The thread is used both in warp and weft. The price is about Rs. 4 per seer (2 lbs.). The price of a *chadar* made with *ghicha* thread measuring $3\frac{1}{4}$ yds. $\times$ 56″ and weighing about 14 *chattaks* (28 ozs.) is about Rs. 8.

Spun thread :—Spinning is done of cocoons boiled as above on the *taku* or *takuli* (Fig. 90) or on the hand spinning wheel (*charka*) or on a *dhera* which is similar in construction to *taku* but with a wooden weight in the form of a cross and much larger and heavier than *taku* and ordinarily used in jute or sunhemp spinning. About two tolas ($\frac{4}{5}$oz.) of thin thread can be spun on the *taku,* 4 tolas ($1\frac{3}{5}$oz.) on the *charka* and about six tolas ($2\frac{2}{5}$oz.) on the improved pedal *charka* in a day. From other kinds of waste about the same quantities of thin thread are spun. But on the *dhera* and improved *charka* about 4 *chattaks* (8 ozs.) and six *chattaks* (12 ozs.) respectively of coarse thread can be spun in a day of eight hours. Women generally spin on *taku, charka* and *dhera* and men on *dhera* and improved pedal *charka.* The price of the thin thread is about Rs. 4 per seer (2 lbs.) whereas, the coarse

thread is sold at the rate of Rs. 2-8-0 per seer. Finer yarns are used for shirtings, *dhoties*, coatings and *chadars* and the coarser yarn for *chadars* and coatings. A coarse *chadar* weighing one seer (2 lbs.) costs about Rs. 4-8-0 whereas one *dhoti* piece weighing six *chattaks* (12 ozs.) costs about Rs. 4 only.

Women of weaver class generally spin finer yarns, whereas, coarse yarns are spun by men of other castes. Many Santhal and Ho rearers are now taking to spinning. Silk merchants give tasar waste to some persons who spin for them at Re. 1 per seer of spun thread. There is a village named Kurpat about five miles from Bhagalpur where all the villagers, both men and women, numbering about 300, spin tasar waste. They earn on an average about As. 3 per day. They sell yarns spun on their own account to dealers at Rs. 2-8 per seer. They do not spin finer counts. Neighbouring villagers are also taking to this industry. These people are directed to put as little twist to the thread as possible because under twisted thread gives better cloth through beating at the time of weaving. It is difficult to procure large quantities of spun yarn in one place. One must wait and arrange with the spinners previously if sufficient quantities are required. Some spinners come to dealers for selling their yarn but their number is small. Weavers generally get wastes spun by their womenfolk and weave the yarn into cloths and seldom sell it. There is no regular market for spun thread. One must collect it from different villages and in small quantities. In the Bhagalpur market alone about Rs. 60,000 worth of coarse hand-spun and hand-woven *chadars* are sold now-a-days in a year. No such industry existed here about ten years ago. In Manbhum, Singhbhum, Gaya and Santhal Parganas District in Bihar and in Mankar, Bishnupur, Dainhat and Bankura in Bengal fine hand-spun *chadars* and coatings, shirtings and loin cloths are woven. Their value would come to about Rs. 1,50,000.

Weaving :—Sago is a good sizing material for *kete*. Take sago 20 to 25 per cent of the weight of yarn to be sized. Soak it in cold water for three hours, then boil thoroughly for a long time in sufficient quantity of water until the globules are dissolved. The size should be thin and should look like transparent water. Steep the yarn in the size for 30 minutes, stirring it all the time. Squeeze out the extra size, wind the sized yarn on to a drum in moist condition and dry it in the shade. Fill the warping bobbins and then warp.

Thin gruel of sun-dried rice is used in place of sago in the Singhbhum District. At Bhagalpur sun-dried rice *conjee* is widely used for sizing coarse hand-spun tasar.

Ordinary hand-looms used for cotton are suitable for *kete* weaving. Both fly-shuttle and throw-shuttle looms are used. In the villages the latter are preferred. Power-looms are not at all suitable. Bamboo reed is preferable to iron or brass reeds. Some weavers use one thread in the warp instead of two and put coarse thread in the weft.

104. Bleaching of *tasar* and *kete*.

For deep shades bleaching need not be done but for light shades bleaching is necessary.

Degumming :— (1) 20 % soap.
3 % washing soda.
Water—20-30 times of the material.
Boil for two hours.
Wash thoroughly.

(2) Steep the silk overnight in 2 twad. hydrochloric acid about 12 hours. Then wash well in cold water. Scour (boil) it for about half an hour in 10 per cent soap and 2 per cent washing soda ; wash well in hot water and then in cold water.

Bleaching bath— for fine (thin) fabrics :—

Sodium peroxide $1\frac{1}{4}$ tola ($\frac{1}{2}$ oz.) per gallon.
Epsom salt $\frac{3}{4}$ tola ($\frac{3}{10}$ oz.) per gallon.

Soft water—20-30 times.

Wash thoroughly.

Soaping :— Soap ... 5%.
Soda ... 2%.
Water ... 20-30 times.
Boil for ½ hour.
Wash, finish with acetic acid and dry in shade.

For thick fabrics, the bleaching bath should be made as follows :—

Water	... 20 times of the weight of silk.
Sunlight soap	... 12½ % of the weight of silk.
Sodium peroxide	... 2% of the weight of silk.
Caustic soda	... 4% of the weight of silk.
Liquor ammonia	... ½% of the weight of silk.
Sulphuric Acid	... 5% of the weight of silk.

Pour the water in an earthen, porcelain or wooden vessel. The degummed silk should be soaked in the above solution overnight. The temperature of the solution at the start should be about 170°F and then it should be allowed to cool down gradually. The silk should be completely dipped under the solution. The vessel should be covered with a lid. The cloth should be turned upside down two or three times. Next morning the silk is rinsed with water. The process can be repeated if the bleaching is not satisfactory. The bath can be used for bleaching another piece after adding to it sodium peroxide and ammonia in the above proportion and about half the quantity of sunlight soap and caustic soda. The water should be heated to the above temperature each time and then it should be allowed to cool down.

The solution should be rejected after it has been used for four or five times. After bleaching, the fabric should be boiled in 5 per cent soap and 2 per cent soda for about half an hour and then washed well and finished with 3 per cent acetic acid in cold water and dried in the shade.

105. Dyeing of *tasar* and *kete*.

*Indigenous dyestuffs from barks :—*India boasted of a well-developed art of dyeing with indigenous dyes in the days long gone by. New natural indigenous dyestuffs have been recently produced in the Bhagalpur Silk Institute from the decoction of barks of mango and other trees mentioned below. Dyes in powder and paste form have been prepared from the decoction by evaporation. The speciality of these dyes is that various shades of brown, orange, crimson, grey, yellow and khaki are obtained from the same powder or paste by different fixing agents. Barks are available in villages but not in big cities. Each pound of dye costs about four annas whereas synthetic dyes of equal fastness cost about Rs. 15 per pound. These natural dyes are fast on silk, wool and jute and have got a good lustre.

*Process of dyeing tasar silk with extract of barks :—*Tasar takes basic, acid and direct colours easily but they are not fast. It does not take naphtol and indanthrene colours. Fast and beautiful shades have been obtained from extract of barks.

Take four seers (8 lbs.) of bark. Pound it with wooden or stone hammer. Boil it for three hours in an earthen or enamel vessel at 100°C in 15 seers (3 gallons) of water. Strain the decoction with a cloth. Dye one seer (2 lbs.) of wet silk in the decoction for about half an hour at 60° to 80°C with the addition of about 4 per cent acetic acid. Stir the liquid and continue dyeing at the above temperature for about 15 minutes. Take out the silk and squeeze out the water thoroughly.

Dissolve 5 per cent bichromate of potash in ten seers (2 gallons) of water and heat it to 40°C, then put in the dyed silk. Go on stirring for about half an hour. Continue cooking up to 80°C. Take out the silk. Wash in cold water and then in bath with 3 per cent acetic acid. Dry in the shade. Tobacco brown colour is obtained. Different shades are obtained if 5 per cent alum, copper sulphate or iron sulphate is used in place of bichromate of potash. Alum yields light orange, coppre sulphate blackish brown and iron sulphate grey to black (5 per cent will give grey colour, 1 per cent slate colour and 5 per cent black colour.)

One to 10 per cent of powder or paste of bark dye should be used instead of extract of barks for different shades and tones.

Maroon, yellowish brown, crimson, khaki, dull orange etc., are obtained if the dyed silk is developed with 3 per cent blue salt B, fast yellow salt G.C., fast violet salt B, bichromate of potash, fast orange salt G.C. respectively.

Barks of the trees mentioned below yield practically the same shades if the same fixing agents are used. The colour is fugitive unless fixing agents are used. Decoction from four seers (8 lbs.) of leaves of any of these trees is sufficient to dye about half seer (1 lb.) of silk which should be fixed as above.

The bark of the following trees have been tried and yielded the dyes :—

Mango (*Mangifera indica*)
Tamarind (*Tamarindus indica*).
Simul (*Bombax malabaricum*).
Pipul (*Ficus religiosa*).
Mahua (*Bassia latifolia*).
Asan (*Terminalia tomentosa*).
Arjun (*Terminalia arjuna*).
Palas (*Butea frondosa*).
Babul (*Acacia arabica*).
Tun (*Cedrela toona*).
Jam or Jamun (*Eugenia jambolana*).
Amaltas (*Cassia fistula*).
Plum or ber (*Zizyphus Jujuba*).
Guava (*Psidium Guyava*).
Bor (*Ficus bengalensis*).
Fig or Jagya-dumur (*Ficus glomerata*).
Mahagony (*Swietenia mahagoni*).
Neem (*Melia azadirachta*).
Teak (*Tectona grandis*).
Tal (*Borassus flabellifer*).

106. Finishing of *tasar* and *kete* fabrics.

Steep the woven goods in cold water for a few hours and boil with 5 per cent soap and three per cent soda for half an hour and then take out and wash well. Coloured goods are washed in 10 per cent cold soap solution. A sizing bath is prepared containing two to ten per cent sago or arrowroot (of the weight of silk), three per cent acetic acid and two per cent igepon and water about 10 times the weight of sago. Boil for half an hour. Pass the gruel through a cloth. Mix sufficient water and dip the cloth in the mixture. Squeeze the water out. Dry in the sun for about 25 minutes until the moisture is reduced to about 10 to 15 per cent. Then place the cloth in thick folds on a *kundi* (round and polished block of tamarind or *bael*, about 1 to 1½ ft. in diameter and 3 ft. in length and fixed in the earth horizontally with half its thickness remaining above the surface of the ground. Then beat it with two wooden clubs for about twelve to fifteen minutes and then iron or calender.

The reader may consult the chapter on Tasar Silk in the " Report on an Inquiry into the Silk Industry in India (1915) " by M. H. Lefroy, Vol. I, p. 118, where an account of the history of the industry with references to literature will be found.

107. Lines on which research is necessary on *tasar* silk.

1. The worms require to be studied in order to find out and distinguish the varieties according to their voltine character, hibernation, etc. Hampson (Fa. Br. India, I, 19) distinguishes several forms. The form *mylitta* is the most yellow ; *paphia* is pale brownish-yellow; *nebulosa* greenish brown, clouded with fuscous as far as the post-medial line ; while *cingalesa* from Ceylon is a dark brownish yellow form.

2. Mating of the males and females of each variety should be effected under control. De has succeeded in getting the moths to mate in captivity when liberated in large airy rooms. Captain Coussmaker got the moths of the species with which he dealt, to pair in baskets in Poona. Moths of the Japanese *muga* worm (*Antherea Yamamai*) mate when confined in wide-meshed, bell-shaped baskets about eight inches in diameter and hung up high up under the roof of an open shed.

3. If seed cocoons with different voltine characters be isolated and made available to rearers rearing is expected to be attended with less difficulties than at present. For this purpose rearing of the seed cocoons must be done in separate plantations grown as described below.

4. Out of the three suitable food plants of the worm viz. *asan*, *arjun* and *sal*, *asan* is considered the best and is at the same time known to respond to pollarding and pruning. Experiments should be carried out in growing the food plants in regular plantations. For rearing the Japanese *muga* low and dense plantations of oak (*Quercus serrata*) are established on well-prepared land with seedlings planted about six feet apart and not allowed to grow more than about six feet in height. *Asan*, *arjun* and *sal* plantations should be tried on similar lines. On such plantations rearing of the worm although under natural wild conditions is more under control than on tall and scattered forest trees. About 6,000 to 10,000 cocoons of Japanese *muga* and Chinese *tasar* are reared on an acre of oak plantations. Such plantations will stimulate rearing of the Indian *tasar* worm. The Forest Department can establish them and can expect a revenue out of them.

Such plantations will enable experiments to be carried out at establishing the more desirable Chinese *tasar* in this country. One experiment carried out in the past was not on proper lines. Live cocoons were procured in 1898 and distributed partly to Darjeeling and partly to Chakrata. Those at Darjeeling failed. At Chakrata about 5,000 worms hatched and were tried on different oaks. The trial was not continued (Rev. For. Admin. Br. India, 1897-8, p. 53).

5. As in the case of the *muga* worm occurrence of grasserie and flacherie diseases in the *tasar* worm is evidently connected with the food. Regular plantations will enable a proper investigation about the incidence of the diseases.

6. Reeling of *tasar* cocoons require experiments in order to evolve suitable machinery and methods on the same lines mentioned under *muga*. *Tasar* reeling was done in the past in Bajarpara and Narayanpur factories in Murshidabad District.

PART XI.

SILK WEAVING AND OTHER MANUFACTURES.

108. General features.

A GENERAL description of the utilisation of silk in various kinds of manufacture has been given in section 7. For detailed information as regards similar utilisation of silk in India and Burma the excellent monographs prepared and published by Government on silk fabrics produced in the different provinces should be consulted. These monographs contain the results of investigation about 1899. A general account of the conditions about 1915-16 is given by Lefroy, (Report Silk Ind. India, Vol. I) who refers to these monographs. More recent information will be found in the Tariff Board's Written Evidence on Sericultural Industry, Vol. I, 1940.

In the first two periods mentioned above mercerised cotton used to be practically the only fibre which could be used and passed as a silk substitute in some cases. Instances are mentioned by Lefroy. By the third period rayon and staple fibre variously known as artificial silk or art silk or alpaca (see section 8) came to stay as the most plausible silk substitutes which could be passed off as silk not only to unlettered village folk but even to better classes of people on account of their ignorance as to the real nature of the substitute and mainly inability to distinguish between silk and the artificial fibre. The latter had a further advantage in its cheapness to recommend it. Rayon is now largely used in place of raw silk and staple fibre in place of spun silk. Invention and use of silk substitutes, especially rayon, created a confusion between silk goods and art silk goods to the detriment of the former. Countries in Europe and America manufacturing and consuming both silk and art silk goods felt about 1932 the necessity of a widespread propaganda at great cost to which Japan contributed liberally in order to acquaint consumers of the real nature of art silk and silk goods and distinctions between them. Various countries have adopted and enforced by legislation the use of the word ' rayon ' for art silk and prohibited by law the use of the word ' silk ' in the case of rayon and staple fibre goods and have also enforced marking and labelling in order to distinguish silk fabrics from rayon and silk mixed fabrics which are liable to be taken or passed off as silk. Such legislation is very necessary and overdue in India. Silk weavers at present indiscriminately weave either pure silk or pure rayon or mixed fabrics of silk and rayon. A discussion of silk weaving has to take rayon into consideration and even cotton for certain classes of mixed goods.

The silk goods produced either pure or mixed, are used in the country. There is practically no export trade in these products, there being on the other hand large imports of many kinds of goods as will be evident from the figures given below. In fact sale of the goods woven in different provinces is mostly confined to the area of production and the fabrics are mostly special products intended to meet localised tastes and fashion. Thus *saris*, *dhoties*, etc. woven in Bengal are mostly used in Bengal and similar is the case for weaving apparel in Burma, Madras, Bombay, Kashmir and U.P. Only some special products of Benares, Vishnupur in Bengal and certain classes of Madras and Mysore *saries* find their way to other provinces. A general idea of the goods produced in different regions or zones will be formed from the list gathered from the Tariff Board's report mentioned above and given in section 113 and also that of the extent of silk weaving in different places from the number of looms in use given in section 110 and from the quantity of raw materials used as shown below and an idea of the possible expansion from the quantity of goods imported also shown below, if they can be replaced by home production. In these figures rayon and staple fibres are included. It will be evident that the major portion of weaving is done on hand-looms. The Tariff Board (1940) estimated that about 40,00,000 lbs. represented normal consumption of raw silk in India out of which 15,00,000 to 20,00,000 lbs. were produced in India and about 20,00,000 to 25,00,000 lbs. were imported. In 1937-38 the imports into India (excluding Burma) of raw materials were as follows :—(Written Evidence, Vol. I, p. 1055-56).

Raw silk	...	25,35,274 lbs.
Silk yarn	...	23,37,288 lbs. including spun yarn ... 15,84,298 lbs. noil yarn ... 4,74,911 lbs.
Silk piecegoods	...	2,77,01,000 yds. (average of five years).
Mixed silk goods	...	86,62,000 yds. (average of five years).
Staple fibre	...	26,81,935 lbs.
Rayon yarn and staple fibre	...	3,15,89,038 lbs.
Rayon piecegoods	...	8,96,94,938 yds.

109. Raw materials used by silk weavers.

The raw materials used by silk weavers in India fall under the following categories :—

I. *Silk threads :—*

(1) Raw silk reeled fine (section 77 to 82).
(2) Raw silk reeled coarse (section 82).
(3) *Matka* or hand-spun silk (section 87).
(4) Hand-spun *eri* silk (section 91).
(5) Tasar raw silk reeled (section 100).
(6) *Kete* or hand-spun tasar (section 103).
(7) Muga raw silk reeled (section 97).
(8) *Era* or hand-spun muga (section 97).
(9) Spun silk, a uniform yarn spun in spinning mills from silk wastes. A little spun silk is also manufactured from *eri* cocoons and from tasar and muga wastes (section 87). How the different kinds of silk threads are produced or obtained has been described in the sections indicated within brackets.
(10) Spun silk mixed.
(11) Gold and silver thread.

In much of the best silk fabrics woven in India gold or silver thread is used for ornamentation in designs. This thread is either imported from Europe or made in India. The process of manufacturing the thread as described by Lefroy is as follows : " A bar of silver is coated heavily with gold leaf and the leaf is fixed on by hammering ; it is then drawn through holes in steel plates, at first by means of a winch ; each hole is a trace smaller than the last : at each drawing the bar elongates : always the gold leaf overlays the silver : a bar an inch across becomes hundreds of feet of fine thread wound on spools : when it is fine enough, the thread is passed between fine steel rollers and becomes flat. It is then wound spirally round a thick orange thread of Chinese (raw) silk ; the silk thread is drawn through the axis of a steel flyer and the flat thread laid on it so as to cover it. This is a separate branch of the (silk) industry and it uses very neat and efficient methods and machinery " (Report *Silk Industry*, Vol. I, p. 140).

Weaving with threads listed above is possible on handlooms only except in the case of item 1, finely reeled raw silk and item 8, spun-silk, which can be used on power-looms.

Raw silk reeled fine and in recognised grades is really the raw material in demand in all silk-manufacturing countries and for all kinds of silk manufactures in which uniformity in texture, thickness and strength is necessary. How such raw silk can be produced has been described in section 79. Such raw silk is essentially necessary for production of standardised goods. Finely reeled raw silk is also described as filature silk or denier silk.

Spun silk being a machine product is uniform in thickness and presents no difficulties in power weaving.

Tasar and muga raw silks reeled as at present cannot be used in power-looms. These as well as the other threads listed in items 2 to 8 above are used for producing coarse and unstandardised stuff.

II. *Silk substitutes :—*

(12) Rayon, variously known as artificial silk, art silk or as alpaca in some places in India.

(13) Staple fibre.
(14) Staple fibre mixed (Nitto).

How these are produced will be seen in section 8. No rayon or staple fibre is produced in the country. Both the yarns are imported.

III. *Threads for mixed fabrics :—*

Raw silk, spun silk, hand-spun silk, raw tasar, hand-spun tasar, raw muga, hand-spun muga, rayon, staple fibres and cotton are used in the production of mixed fabrics, any of the threads named being used in the warp in combination with another thread in the weft. Gold thread, raw muga silk coloured and uncoloured or even rayon may be used in borders or embroidery. Mixed weaving with silk and cotton has been practised all along as religious scruples, for instance among the Muslims, forbid the use of pure silk fabrics on certain ceremonial occasions.

110. Where silk weaving is practised and approximate number of looms and persons engaged.

The following table indicates the Provinces and States where silk and mixed silk weaving is practised with the number of looms engaged about the year 1937-38. For a comprehensive and comparative idea cotton and wool looms are added but not those weaving durrie.

I. *Hand looms.*

	Pure silk.	Mixed silk and cotton.	Art silk.	Art silk & cotton.	Cotton	Wool, coir, kora grass etc.	No. of persons engaged on handlooms.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Mysore—	3,700	1,500	...	...	2,000	...	30,000
Kashmir— using silk & spun silk	1,000	...	...	...	15,610	29,390	1,84,000
Hyderabad, Deccan—	4,183	70,067	...	...	23,355	...	7,13,762
Bengal—	4,119	10,000	...	...	1,11,311	...	4,84,000
Raw silk— 2,966							
Tasar— 436							
Matka— 717							
Punjab—	6,300	450	22,500	...	2,41,419	...	2,99,754
Raw silk— 1,800							
Spun silk— 4,500							
Madras—	11,204	...	26,195	...	2,45,337	24,336	1,97,724
Bombay—	6,000	42,000	...	5,000	54,000	...	4,30,000
Assam—	1,000	29,000	...	...	4,02,000	...	4,32,000
Behar—Tasar—	733	1,971	...	...	89,837	...	3,80,000
U.P.—	51,600	...	...	...	1,64,800	28,400	7,55,200
C.P. & Berar—	10	9,500	...	...	59,617	...	73,338
Orissa—	897	584	...	420	...	...	7,600
Sind—	113	130	...	...	846	...	3,488
Delhi—	20	...	...	...	1,120	...	4,400
Burma—	50,000	...	...	...	1,00,000	...	...
Indore—	5	170	...	...	75	...	1,000
Patiala—	24	100	...	...	6,375	...	6,500
Cochin	...	500	...	...	2,000	...	5,000
Gwalior	...	...	...	...	1,500	...	4,000
Total	1,40,888	1,65,972	48,695	5,420	15,21,202	82,126	40,11,766

These figures should be taken as approximate. No figures are available from N. W. Frontier Province, Coorg, Baluchistan, Travancore and several other States.

Also there is some confusion about the looms using pure silk or silk only in borders of *sarees, dhotis* and *chadars*. No figures are given in Bengal of the latter class of looms although the practice is wide and a conservative estimate of 10,000 looms under mixed goods is added. Mixed weaving is also practised in U.P. and Madras and the silk looms recorded may include those producing mixed goods. Art silk mentioned in the table includes rayon and staple fibre.

The Punjab reported 22,500 and Madras 26,195 handlooms weaving rayon and staple fibres and U.P. reported 2,100 weavers engaged in similar weaving. In Bengal too such weaving has been undertaken, also weaving of rayon and silk mixtures. But the number of looms engaged is not known. Art silk weaving on handlooms is at present more extensive and most probably in all areas than indicated in the above figures.

II. *Power looms.*

A. *Silk mills.*

No correct figures about the number of power-looms are available. Besides it is not possible to distinguish looms doing raw silk, art silk, spun-silk, staple fibre or wool as all these can be and are done on the same looms and in the same mill according to opportunity and demand. The following is the number of silk mills recorded by the Tariff Board (Written Evidence, I, 1940 pp. 1262-77). A list was supplied by the Deputy Director of Statistics, Calcutta, which was verified and added to by the Provincial and State Directors.

Province and place.	No. of mills.	Total No. of looms.	Average No. of workers employed daily (1937-38)	Remarks.
Bengal—				
24-Parganas District	6	471	1,275	Director of Statistics.
Bombay— ...				
Ahmedabad ...	6	...	180	Director of Statistics.
Poona	1	...	...	Added, but workers not noted.
Broach	1	...	...	Do. Do.
Bombay	3	...	204	Director of Statistics.
	21			Added but workers not recorded.
Surat	41	...	1,089	Director of Statistics.
Madras—				
East Godavari, Coimbatore and Bellary ...	6	...	469	Director of Statistics Only 2 power-driven.
Mysore	...	400	...	
Punjab—				
Lahore, Ludhiana ...	5	...	532	Director of Statistics
Amritasr ...	18	...	894	Added by Director of Industries; 8 are recorded as using hand-looms only.
U.P.—				
Saharanpur and Benares	2	...	59	...

Province and place.	No. of mills.	Total No. of looms.	Average No. of workers employed daily (1937-38)	Remarks.
Sind	1	...	37	Director of Statistics.
	6	...	...	Added but workers not noted.
Kashmir	9	...	304	Director of Statistics. Only one power-driven.
Hyderabad (Deccan)—				
Hyderabad city ...	2	...	80	Director of Statistics.
Aurangabad ...	2	...	40	Added by Director of Industries.
Mysore—				
Bangalore ...	32	...	1,365	Director of Statistics.
Mysore	12	...	44	Added by Director of Industries.
Total ...	174	871	65-72	

The number of looms are not recorded in the mills except in Bengal. The mills recorded by the Director General of Statistics are evidently silk manufacturing mills, using raw silk, spun silk and occasionally rayon and wool. Mysore reported 400 power-looms engaged in silk weaving.

B. *Art silk mills :—*

The protective duties imposed on imported artificial silk goods on the recommendation of the First Tariff Board on Sericulture led to the starting of many so called silk mills, really rayon goods manufacturing mills in India. The machinery were Japanese and Japanese technical staff and engineers were imported.

With a duty of five annas per lb. of rayon yarn and six annas per square yard of rayon cloth it proved sufficiently attractive to undertake manufacture of rayon cloth in India as one lb. of rayon yarn yielded about seven to eight yards of cloth. It was reported that about 60,000 looms, mostly imported from Japan, were engaged in rayon cloth manufacture. This cloth became a serious competitor not of silk but of cotton, so much so that the Indian Central Cotton Committee was proposed to be approached with a request for increasing the duty on rayon yarn (Tariff Board Written Evidence, I, 1940 p. 461). The rayon mills on the other hand soon found out that probably on account of this work being new to Indian workers and also on account of imported technical staff and machinery the cost of production as well as capital and overhead charges were high. The yarn was imported and had to pay a duty. To take one example, for plain *shiozie* with rayon warp and weft, 90 ends and 60 picks, the C.I.F. price of fabric imported from Japan was 1 anna 3 pies per yard while that manufactured in India cost 4 annas 6 pies per yard (Indian Tariff Board. Sericulture, Written Evidence I, 1940 p. 1031).

It is unfortunate that there was no expert organisation to guide this work and it is mostly capitalists with enough money in hand who rushed into this business. Most of these mills had to remain idle during the war for want of rayon yarn. It would have been wise to devote this capital in setting up rayon yarn manufacturing plants.

111. Kinds of looms in use.

The hand-looms in use are of various types. The *pit-loom* is of simple construction consisting of :—

(1) a wooden slay with locally made bamboo reed;

(2) two shafts with cotton string healds knitted for every new warp round the warp threads ;

(3) a take-up beam on supports ;

(4) a warp beam which can be let out with the help of a cord by the weaver himself ;

(5) a pair of pedals usually placed in a pit in the ground and worked by the feet of the weaver who sits on the edge of the pit.

In Assam the loom is hung from four upright bamboos. In some cases in factories the loom is fixed on a wooden frame (frame loom).

The shuttle is thrown with hand from side to side and beating is done by pulling the slay with hand (throw-shuttle loom).

Fly-shuttle loom, an improvement on throw-shuttle loom, has a slay with shuttle boxes at the ends and the shuttle is pushed from end to end across the slay by pickers attached to a string arrangement pulled with right hand from side to side while beating is done by pulling the slay with the left hand.

A further improvement on the fly-shuttle is the automatic slay in which the shuttle is pushed from side to side by the simple beating motion of the slay (automatic shuttle loom). The fly shuttle and automatic slays are generally adapted and attached to and worked with pit looms.

The above three types are the hand-looms in use. Improved metal reeds and made-up healds of cord or wire are sometimes adopted. The majority of the looms in use are of throw-shuttle type. Next comes fly-shuttle and next automatic shuttle. Here and there automatic looms worked by pedals and Hattersley, Japanese and Churchill looms may be present but they are not many.

There are modifications in the above descriptions of looms for different kinds of weaves.

The simple two shaft loom is suitable for plain weaves.

For twills and simple patterns the loom is fitted with four shafts worked by as many pedals.

For intricate designs eight or twelve shafts with as many pedals are used.

In some cases separate shafts work only the warp threads of the borders.

Dobbie and Jacquard frames are frequently attached to the hand-looms for weaving designs and hand punching implements are used for punching cards for Jacquard weaving.

Kinkhab or brocade hand-looms are very complex in design. Pairs of healds are connected separately to strings which are taken upwards and worked from above. Combination of strings and healds manipulated successively works up half of a pattern which is completed by reversing the order. Combining this with double or treble warps and border warps and with the help of separate spools or shuttles for embroidery with any coloured thread or gold and silver threads worked with hand, beautiful and elaborate brocades or *kinkhabs* are woven.

Power-looms are worked with electricity and for flowered and pattern weaving are fitted with Jacquard frames.

112. Kinds of cloth and other articles manufactured in India.

As pointed out in section 108 different weaving centres weave different kinds of cloth. A general description of pieces woven is as follows. There are other local names as will appear from the lists below.

Saree is a piece of cloth with wide borders worn by women. The size in use differs in different parts of India. In South India its length is 8 to 9 yards while in North India 5 to 6 yards. The width everywhere is 44″ to 46″. *Sarees* form the major portion of manufacture with all kinds of thread (section 109). Ornamentation in borders, in the body and at one end (*anchal* or *anchla*) in costly pieces with coloured and gold and silver

threads in infinite patterns and designs is carried out to beautify the *saree* and naturally its price increases proportionately to ornamentation. Cotton *sarees* have frequently only silk in the borders. A *saree* has frequently a bodice or blouse piece, one yard in length, woven along with and sold with it which is cut out and made into a bodice to match the *saree*.

Dhoti, *dhooty* or *dhuti* is a piece of cloth worn by men. Its size in North India is about 5 yds. × 44″—48″ and in South India 3-4 yds. × 52″-54″. It is usually a plain piece often without any distinct border or may have a narrow coloured or uncoloured silk or gold and silver thread border. *Makhtam* or *makutam* of South India is a kind of dhoti. *Pitambar* of Western India is a *dhoti* of pure silk.

A *chadar*, *dupatta* or *angabastram* or *shawl* is a piece, 2½ to 3 yds. × 44″-45″, used on the body by men and is usually woven on the same style as a *dhoti*.

A *jore* is a *dhoti* and *chadar* woven and sold together. It is coloured or uncoloured and is worn by the bridegroom at the time of marriage in North India.

Longy, *lungi* or *loongi* is worn both by men and women in Burma but usually by men in India. It is a cut piece, usually 2 yds. × 44″-46″, the cut edges being sewn up so that the wearer does not wrap it round the body like *dhoti* and *saree* but slips it on either over the head or legs first. Women's *lungis* are frequently ornamented in the lower borders. The body of all *lungis* is usually coloured and woven either in checks, basket patterns, shot or may be in one uniform colour.

Than is a word used in Bengal to describe pieces which have to be cut for use and includes shirtings and suitings. It is however specifically used usually for heavy qualities well woven with twisted and bleached silk, in plain or twill weave and may be uncoloured, coloured or in stripes and checks. This used to be exported to Europe in the early days of the industry but has been ousted from the market for want of standardisation.

Matka-than, *tasar-than*, *eri-than*, *kete-than* are pieces made with hand-spun *matka*, tasar raw, hand-spun *eri* and hand-spun tasar respectively.

Malmal is used in Bengal to describe fine fabrics of good quality such as muslin, chiffon, etc.

Bafta is the general name for pieces woven with tasar silk and cotton yarn.

Daryai, *Gulbadan*, *sangi*, (U.P. and the Punjab) are *thans* with waved effect.

Mashru (Bombay, Deccan, U.P.) is woven with silk and cotton so as to make the fabric permissible to Muslims.

Satinette is cotton back satin, woven so that the smooth silk is seen on one side and the cotton warp on the other.

Kinkhwab, *Kinkhab* or *Kamkhwab* is a piece which is woven in a great variety of designs worked with gold and silver thread. The piece may be of silk or silk and cotton. *Kinkhab* pieces are very costly. That without gold and silver thread known as *amru* is cheaper.

Korah or *korah-than* (Bengal) is a plain piece woven with untwisted raw khungru silk and degummed after weaving, in lengths varying from 7 to 50 yards. *Korah* (literally unwashed) pieces used to be extensively exported to England from Bengal to be boiled, printed and finished there. This is the plain white or cream cloth used largely in European countries for making dresses, linings, etc. Its place has been taken by Japanese *habutae* mainly through standardisation. Bengal *Korah* suffered for want of standardisation and disappeared from the foreign market. At present it is used for printed *sarees* and in such cases made in *saree* or *saree* and blouse piece lengths.

Embroidery and miscellaneous manufactures :—Embroidery (*phulkari*) with silk on cotton, spun silk, woollen fabrics or in the weaving of silk and wool (*pashmina*) is practised in U.P., the Punjab, Kashmir, North Western Frontier Province, Gilgit, Bokhara, etc. The silk used is a very coarse one which gives a very thick flossy thread. Very coarse *ghora* silk of Bengal or even long reeling waste or wastes cocoons are used. The silk is dyed.

Fine embroidery is practised all over the country but with differently coloured yarns mostly imported.

Borders of woollen shawls mainly for Bengal market and also other parts of India are woven in various complicated designs in Kashmir. Silk 18/20 denier is used in twisted and doubled condition and dyed in various colours. The pattern is woven with hand by working the threads on small wooden quills. It is more like carpet weaving.

Silk is also used in North India for making *huqa* (hubble-bubble) tubes, buttons, silk braid and plaited frinzes, armlets and strings for ornaments.

Silk carpets are woven in Kashmir for the American market with thick dupion or *ghora* silk dyed on cotton yarn foundation.

113. Fabrics manufactured in different areas.

The following lists of cloths manufactured in different areas are gathered from the Written Evidence, Vol. I, 1940 before the Tariff Board.

Mysore hand-loom products.

Description	Size
Saree ...	8-9 yds. × 44″-46″
Kanam (bodice) ...	Piece 9 yds. × 32″ for 16 *kanams* or 27 yds. for 48 *kanams*.
Angabastram (dupatta) ...	$2\frac{1}{2}$ yds. × 45″.
Makutam (dhoti)	4 yds. × 48″.
Handkerchiefs	18″ × 18″.
Shirting	Piece 50 yds. × 36″.
Plain piece	60 yds. × 36″.
Cotton *saree* with silk border ...	8-$8\frac{1}{2}$ yds. × 42″-44″.
Cotton *lungi* with silk border ...	Piece for a pair, 8 yds. × 54″.
Cotton *lungi* with mercerised border	8 yds. × 50″-54″ (pair).
Cotton *dhoti* with silk border ...	3-4 yds. × 40″-54″.
Cotton mixed art silk *saree* and *dhoti*	Sizes as above.

Products of Government Silk Weavnig Factory, Mysore.

Sarees—
- Georgette.
- Crepe-de-chine.
- Fancy georgett and crepe.
- Laced georgette and crepe.

Dhotis— Interlaced silk fabrics.
Satins.
Shirtings and coatings.
Handkerchiefs.
Ties.
Pongee.

Kashmir & Jammu—	*Sarees*—	6 yds. × 45″.
	Dupattas—	3 yds. × 54″.
	Handkerchiefs—	24″ × 24″.
	Gown pieces—	25 yds. × 45″ wide.
	Shirtings—	25 yds. pieces 27″ wide mixed with spun silk.

Spun silk is mostly used for embroidered bed covers, curtains, table covers and inferior sort of shirtings.

The silk weaving factory produces on power-looms georgette, crepe-de-chine and satins.

Patiala— *gulbadan*, *phulkaris*, *sarees*, *dupattas*, *lungis*, suitings, shirtings and gown pieces.

Travancore—	*Sarees*, *dupattas*, *angalastram*, shirtings and coatings, with spun silk mostly.	
Bengal—	*Sarees*—	5 to $5\frac{1}{2}$ yds. × 44″ to 46″; warps of 100 to 180 yds.
	Dhotis—	5 yds. × 44″.
	Jores—	8 yds. × 44″.
	Shirting—	10 to 12 yds. × 36″.
With bleached and twisted silk	Handkerchiefs—	15″ to 22″ × 15″ to 22″.
	Turbans—	12 yds. × 44″..
	Gown pieces—	10 yds. × 36″ to 40″ in warps of 80 yds.
	Chadars or *dupattas*—	3 yds. × 48″-54″ in warps of 90 yds.
	Than suitings—	8 yds. × 32″.
With unbleached untwisted silk	*Saree* with blouse piece	$6\frac{1}{2}$ yds. × 45″.
	Korah or *Korah-than*	9 yds. × 40″.
	Jore—	8 yds. × 44″.
With tasar silk—	*Saree*—	$5\frac{1}{2}$ yds. × 45″.
	Dhoti—	5 yds. × 44″.
	Than, shirting and suiting—	16 yds. × 28″.
With *Matka*—	*Saree* and *dhoti*—	5 yds. × 44″.
	Chadar—	3 yds. × 54″.
	Than, suiting and shirting—	12 yds. × 36″.
Punjab—	This province produces small quantities of *sarees*, shirtings and suitings but specialises in *daryai*, *gulbadan* cloth, mushadi *lungis* and *tahmats*.	
With spun-silk in warp and raw silk in weft—	Suitings and shirtings, *daryai*, *lungis*, *tehband*.	
With spun silk, in warp and weft, artificial silk, gold thread—	*Pagris*, *tehbands*, *gota*.	
With silk yarn	*Daryai* and *gulbadan*— Piece 72 to 75 yds. × $22\frac{1}{2}$″.	
	Mushadi *lungi* and *lungi* with gold thread $5\frac{1}{2}$ yds. × 20″.	
With spun silk—	Suiting and shirting—	27″ to 29″ wide.
	Saree—	5 yds. × 45″.
	Daryai—	72 to 75 yds. × $22\frac{1}{2}$″.
With artificial silk—	Boski, plain—	27″ to 29″ wide.
	Shirting striped—	27″ to 29″ wide.
	Saree—	5 yds. × 45″.
	Daryai—	125 yds. × $22\frac{1}{2}$″.
Bombay—	*Kinkhab* on cotton	5 yds. × 24″ to 36″.
	Silk *saree* with gold thread—	8 to 9 yds. × 45″.
	Silk *lungi*—	$2\frac{1}{2}$ yds. × 45″.
	Silk satin—	12 yds. × 26″.
	Silk coating—	30 yds. × 27″.
	Silk *pitambari*—	8 yds. × 45″.
	Silk *kad*—	5 yds. × 50″.
	Silk *khand*—	4 yds. × 36″.

Assam—	*Pat* (i.e. silk) Mekhala, silk with gold lace embroidery and borders or with muga embroidery	2½ yds.×35″.
	Pat Riha with gold lace or muga borders—	4 yds.×22″.
	Spun silk Mekhala with muga borders—	2½ yds.×35″.
	Spun silk Riha with muga borders—	4 yds.×27″.
	Muga pieces for shirting or suiting—	10½ to 12 yds.×33″ to 36″.
	Muga *pat* piece—	10½ to 12 yds.×33″ to 36″.
	Muga turban with red cotton borders—	6½ yds.×20″.
	Muga turban with silk borders	8 yds.×27″.
	Muga shawl with white silk flower borders—	2½ to 3 yds.×45″ to 54″.
	Muga *saree* with red border—	5 to 5½ yds.×45″.
	Pat saree with muga flower or red silk border—	5 to 5½ yds.×45″.
	Pat dhoti—	5 yds.×45″.
	Pat chadar—	3 yds.×54″.
	Pat shawl with muga flower border—	3 yds.×54″.
	Spun silk *saree* with muga flower border—	5 to 5½ yds.×45„.
	Spun silk *chadar*—	3 yds.×54″.
	Handspun *eri* shawl with muga borders—	3 yds.×54″.
	Handspun *eri* piece for use as *chadar*	3 yds.×54″
	or for suitings	6 to 7 yds.×54″.
	Khasi *saree* in yellow red, black or white silk with flower borders—	4 yds.×36″.
	Bar pagree (big turban)—	6 yds.×36″.
	Teri or *Tel Kapor* or silk screens in red and blue stripes for Garos and Khasis—	2½ yds.×35″.
	Teri or *Tel Kapor*, spun silk warp and cotton weft—	2½ yds.×45″.
Indore—	*Saree*—	9½ yds.×54″ to 60″.
	Dupatta—	5 yds.×50″.
	Shirtings and suitings—	Pieces 30″ wide.

Cochin—Use of silk is limited to borders of *sarees*, *dhotis*, etc.

Gwalior—In addition to usual *sarees* etc. *khan* pieces, turbans, sofas, blouse pieces, etc. are woven.

Madras—	*Sarees*—	8 yds.×45″.
	Dhotis, *angabastram* (body wraps) handkerchiefs, turban cloths, suitings and shirtings, blouse or bodice pieces	Sizes about the same as shown in Mysore.

Raw silk, silk yarn, art silk, staple fibre, spun-silk and gold thread are used for weaving.

Bihar—Raw silk, raw tasar, hand-spun *eri*, spun-silk, noil, rayon and staple fibre are used in weaving fabrics.

Raw tasar, spun silk, staple fibre are used for warp and cotton yarn, hand-spun *eri*, noil, raw tasar and raw silk in the weft. Tasar and cotton mixed fabric is called *bafta*.

Saree—	$5\frac{1}{2}$ to $6\frac{1}{4}$ yds. × 44″ to 45″.
Lungi (6 pieces)—	12 yds. × 45″.
Dupatta—	3 yds. × 45″ to 72″.
Handkerchiefs—	18″ × 18″.
Shirtings—	9 yds. × 30″ to 32″.
Suitings—	9 yds. × 20″ to 30″.

Tasar curtains and scarves are woven for European and American markets.

U.P.—The materials woven are:

Spun silk mostly from Japan and a small quantity from Italy.

Spun tasar—	From Japan.
Raw silk—	From Japan, China, Kashmir, Mysore and Bengal.
Thrown silk i.e. silk yarn—	From Japan, Katan and Georgette yarn.
Rayon—	Mostly from Japan.
Staple fibre—	From Japan.
Gold thread Silver thread	From India.

There is no hard and fast rule for the use of the various threads in the warp and weft. Some practices are as follows:—

		Warp.	Weft.
Sarees— *Dupattas*—	5 to 9 yds. × 45″ to 52″. $2\frac{1}{2}$ to 3 yds. × 48″ to 72″.	Thrown silk Thrown silk Thrown silk Spun silk Spun silk Spun silk	Thrown silk. Georgette. Raw silk. Spun silk. Staple fibre. Raw silk.
Brocade—	$3\frac{3}{4}$ yds. × 27″ to 36″.	Spun silk	Raw silk.
Blouse piece (full piece)—	10 yds. × 45″ to 52″.	Katan—	Raw silk.
Suitings and shirtings—	7 yds. × 54″. 14 yds. × 28″.	Various combinations.	
Pot-ka-than for paijamas and lengas		Katan Raw silk	Raw silk. Raw silk.
Raw silk *than*—		Raw silk	Raw silk
Dogabia (check)—		Cotton	Raw silk.
Crepe *saree*— Mixture (striped)		Raw silk	Rayon.
Monia *than* (check)		Raw silk	Raw silk with a few strings of mercerised cotton for check.

Central Provinces and Berar:—

Saree—	9 yds. × 50″.	Silk Cotton Cotton	Cotton Silk Cotton — With a gold thread or silk border.
Dhotis—	10 yds. × 52″.	Cotton	Cotton — Silk border with or without gold thread.

Spun silk and rayon are also said to be used.

Orissa—	Silk *saree*	—	7 yds. × 48″.
	Silk *dhoti*	—	5 yds. × 48″.
	Silk *chadar*	—	90″ × 48″.
	Tasar *saree*	—	7 yds. × 48″.
			6 yds. × 44″.
	Tasar *dhoti*	—	5 yds. × 44″ to 48″.
	Tasar *chadar*	—	90″ × 48″.
	Tasar shirting	—	11 yds. × 36″.

Sind :—Raw silk, thrown silk, spun silk, rayon and gold thread are used.

Daryai, *dupattas*, shirtings and suitings, *lungis*, handkerchifs, and brocades are woven.

Delhi :—Raw silk, raw tasar, spun silk, rayon, staple fibre and cotton yarn are used.

Sarees, *lungis*, shirtings and suitings are manufactured.

Burma—	Silk *lungi—*	$1\frac{3}{4}$ to 2 yds. × 44″ to 46″	Woven mostly in widths of about 22″ and then sewn up lengthwise.
	Paso—	4 yds. × 44″ to 46″.	This is more pretentious than *lungi*. *Yawpaso* is black or dark-blue with patterns woven with embroidery shuttles with hand.

Mills manufacturing silk and artificial silk goods make use of :—

Raw silk, spun silk, rayon, staple fibre and cotton yarn and produce both pure and mixed goods.

They, too, manufacture *sarees* to a large extent and other goods plain, taffeta, shioji, boski, crepe, georgette, voila, satin, etc.

114. Kinds of cloth which are imported.

The Japanese Chamber of Commerce, Bombay, has recorded the following, imported from Japan—(ibid, pp. 1047-48); section 116 indicates how they are manufactured and with what raw materials.

A. Silk tissues including cotton mixtures :—

Habutae, Kaiki, satins, taffettas and poplins, Chiffon, Pongee, Fuji silk, Kabeori, crepes, noil, and others.

B. Artificial silk and mixed tissues :—

Habutae, taffetas and poplins, satins, crepes and Kabeori, voil, figured tissues, check, striped weaves, twill weaves, Nashijiori, and others.

The Chinese Vice-Consul, Bombay, classified silk piecegoods imported from China as follows (ibid, p. 905).

Silk piecegoods
Silk, pongees, Honan
Silk, pongees, Shantung
Silk, pongees, other kind
} (Evidently hand-loom products).

The following fabrics are recorded to be imported through Karachi port (ibid, p. 1092).

Silk manufacture hosiery, socks and stockings made chiefly of silk.

Silk piecegoods pongee.

Crepes and georgettes.

Sateens and taffettas.

Silk piecegoods, others.

Silk manufacture, goods of silk mixed with other materials.

Silk manufacture, other sorts.

Artificial silk manufacture, hosiery, socks and stockings made chiefly of artificial silk.

Artificial silk piecegoods made entirely of art silk.

Goods of artificial silk mixed with other materials containing 50 per cent or more of cotton.

Goods of artificial silk mixed with other materials containing no cotton or less than 50 per cent of cotton.

Artificial silk manufacture, other sorts.

The Kathiawar ports (ibid, p. 1198) record practically the same goods.

115. Standardisation of farbrics in Japan.

Silk fabrics for wear are woven in different weaves, in different lengths and breadths and in different thickness as required by the people of different countries. Different kinds of fabrics are known by different names.

In Japan generally speaking the silk fabrics are classed into (ibid, p. 1157) :—

I. Broad weaves (width 20 inches and above).

Crepe-de-chine and georgette. Habutae. Raw satin. Fuji silk. Pongee. Satin. Cloth for umbrellas and parasols. Velvet. Others.

II. Narrow cloth (width 18 inches or less).

Crepe-de-chine. *Habutae*. *Ro* and *sha* (gauze silk). *Meisen* and *Fushori*. *Ito-ori*. Cloth for Japanese trousers. Plain silk. Others.

III. Special products.

Cloth for men's sashes. Cloth for women's sashes, broad and narrow ribbons and tapes. Others.

The special products and narrow cloths are mainly for home consumption. The broad cloths are largely exported. All goods for export apart from the broad classification indicated above for general dimensions and weave are standardised for (a) specific dimensions i.e. length and breadth of pieces, (b) thickness of the fabric indicated by the Japanese word *Momme-zuke* which has now become current to indicate thickness of a fabric like the French word denier for raw silk thread, (c) number of threads to be used in warp and weft, (d) warp and weft threads to be single or double or treble, (e) freedom from weaving defects and (f) finish. Export goods are required to be manufactured according to specifications and all export pieces are required to be submitted to export cloth examining centres described as Cloth Conditioning Houses which examine each piece and stamp it. Pieces which do not satisfy specifications are rejected and not permitted to be exported and are utilised at home. Goods used at home have to pay taxes.

The principal silk goods exported from Japan are broadly the following :—

A. Woven with raw silk and then degummed by boiling and finished. Crepe silks (crepe-de-chine, georgette, kabe crepe, satin crepe) which are not weighted with tin salts unless desired. Loading with tin salts is practised largely in western countries to add to thickness, lustre and hardness of feel but at the expense of durability. These silks are made in piece dyed, yarn dyed, striped, brocaded and printed patterns.

Habutai or *habutae*, plain, twill or satins either natural white or dyed and also in striped, figured and brocaded patterns.

Shike silk and thin silk (or *Usu Ginu*) like *habutae* but of inferior quality in striped and figured patterns.

Pongee silk woven with tasar yarn imported from China and also in striped and figured patterns but these latter on a small scale.

An inferior quality known as *Nippongee* or *Pongeette* is woven with the weft of spun *tasar*. This is required according to inspection rules to be marked with four green threads on both selvages in order to distinguish it from *pongee*.

B. Woven with degummed yarn described as gloss silk and then finished.

Satin—mostly in figured patterns.

Taffeta—coloured and striped.

Kohaku—a taffeta with scarlet threads.

Kaiki—a plain silk with stripes and pictures in colour.

C. Woven with spun or schappe silk.

Fuji silk and soft and spun crepe silk in natural white, piece dyed, yarn dyed, striped, check, brocaded and printed patterns.

Fujette or *Fuji-ginu* when spun-silk is mixed with other yarn and this stuff like *Pongeette* is required to be specially marked.

The export pieces are usually 50 yds. in length except in case of the fabrics under B above which vary from 20 to 26 yds. The width varies from 20 to 54 inches.

116. *Momme-zuke* or momme (thickness of fabric).

Thickness which is taken to denote quality of silk fabrics in Japan is indicated by the term *Momme-zuke* usually abbreviated into m/m or M.M. which means the weight in *momme* (=·1323 oz. or 3·75 grams.) of a piece 1 *sun* (1·49 inches) wide and 6 *jo* (one *jo*=4·14 yds. in Japanese system of cloth measurement) in length or approximately 1 sq. yard. In commercial practice 6 *jo* is taken as 25 yards. Therefore if a piece 25 yards in length and 1·5 inches in width weighs 6 *momme* it is a " 6m/m fabric ".

As regards width the practice is to take	20 inches	as	13 *sun*.
	23 ,,	...	15 ,,
	33 ,,	...	22 ,,
	36 ,,	...	24 ,,
	40 ,,	...	26·7 ,,
	45 ,,	...	30 ,, and
	54 ,,	...	36 ,,

For a 6 m/m—50 yds.×36″ piece the weight is calculated as follows :—

$$6\times\frac{50}{25}\times 24 \ \left(\text{m/m} \times\frac{\text{length in yds.}}{\text{25 yds.}}\times \text{width in } sun\right) \text{ or}$$

288 momme which is the standard weight of such pieces. But all pieces although equal in length and width cannot be expected to weigh exactly the same. Therefore in practice some deviations above and below the standard weight are permitted and in this particular case the minimum and maximum deviations are 276 and 300. If the average of the weights within these deviations of the pieces in a lot is equal to the standard weight the pieces in the lot are taken to be of standard quality. If the average is 2 per cent lighter the pieces are taken as 2 per cent lighter quality and the minimum, average and maximum weights have to be correspondingly lowered. For thin pieces from $2\frac{1}{2}$ m/m to 6 m/m the grades differ by $\frac{1}{4}$ that is $2\frac{1}{2}$, $2\frac{3}{4}$, 3, $3\frac{1}{4}$ and so on. From 6 m/m to 10 m/m the grades differ by $\frac{1}{2}$ and from 10 m/m to 20 m/m by 1 or in some cases by 2.

Tables have been worked out giving minimum, average and maximum weights of pieces of different sizes for the various grades from $2\frac{1}{2}$ m/m upwards and are adhered to in inspection. As these tables are useful for production of standardised goods they are collected from various sources and reproduced below with equivalents worked out in ounces.

Weight Table. (20″ × 50 yds.)

Denoting in "momme" and in corresponding ounces the approximate weight of Japanese silk piecegoods per piece together with tolerable limits for maximum and minimum weights.

Quality Thickness m/m	oz.	Standard weights. Min. m/m	Min. oz.	Av. m/m	Av. oz.	Max. m/m	Max. oz.	2% lighter weights. Min. m/m	Min. oz.	Av. m/m	Av. oz.	Max. m/m	Max. oz.
2½	·33	60	8	65	8·6	70	9·3	59	7·8	64	8·5	69	9·1
2¾	·36	67	8·9	72	9·5	77	10·2	65	8·6	70	9·3	75	9·9
3	·39	73	9·7	78	10·3	83	11	71	9·4	76	10	81	10·7
3¼	·43	80	10·5	85	11·2	90	11·9	78	10·3	83	11	88	11·6
3½	·46	86	11·4	91	12	96	12·7	84	11·1	89	11·8	94	12·4
3¾	·5	93	12·3	98	13	103	13·6	90	12	95	12·6	100	13·2
4	·53	99	13	104	13·8	109	14·4	97	12·8	102	13·5	107	14·2
4¼	·56	106	14	111	14·7	116	15·4	104	13·8	109	14·4	114	15
4½	·6	112	14·8	117	15·5	122	16·1	110	14·6	115	15·2	120	15·9
4¾	·63	119	15·7	124	16·4	129	17	117	15·5	122	16·1	127	16·8
5	·66	125	16·5	130	17·2	135	17·8	122	16·1	127	16·8	133	17·6
5¼	·7	132	17·5	137	18·1	142	18·8	129	17·0	134	19·7	139	18·4
5½	·73	136	18	143	18·9	148	19·6	135	17·9	140	18·5	145	19·2
5¾	·76	145	19·2	150	19·9	155	20·5	142	18·8	147	19·4	152	20·1
6	·79	151	20	156	20·6	161	21·3	148	19·6	153	20·3	158	20·9

Weight Table. (23″ × 50 yds.)

Denoting in "momme" the approximate weight of Japanese silk piecegoods per piece together with tolerable limits for maximum and minimum weights.

Quality Thickness m/m	oz.	Standard weights. Min. m/m	Min. oz.	Av. m/m	Av. oz.	Max. m/m	Max. oz.	2% lighter weights. Min. m/m	Min. oz.	Av. m/m	Av. oz.	Max. m/m	Max. oz.
2½	·33	68	9	75	9·9	82	10·9	67	8·9	74	9·8	81	10·7
2¾	·36	76	10	83	11	90	11·9	74	9·8	81	10·7	88	11·7
3	·39	83	11	90	11·9	97	12·8	81	10·7	88	11·7	95	12·6
3¼	·43	91	12	98	13	105	13·9	89	11·8	96	12·7	103	13·6
3½	·46	98	13	105	13·9	111	14·7	96	12·7	103	13·6	110	14·6
3¾	·5	106	14	113	15	120	15·9	103	13·6	110	14·6	117	15·5
4	·53	118	15·6	120	15·9	127	16·8	111	14·7	118	15·6	125	16·5
4¼	·56	121	16	128	16·9	135	17·9	118	15·6	125	16·5	132	17·5
4½	·6	128	16·9	135	17·9	142	18·8	125	16·5	132	17·5	139	18·4
4¾	·63	138	18·3	143	18·9	150	19·9	133	17·6	140	18·5	147	19·5
5	·66	143	18·9	150	19·9	157	20·8	140	18·5	147	19·5	154	20·4
5¼	·7	151	20	158	20·9	165	21·8	147	19·5	154	20·4	161	21·3
5½	·73	158	20·9	165	21·8	172	22·8	155	20·5	162	21·4	169	22·4
5¾	·76	166	22	173	22·9	180	23·8	162	21·4	169	22·4	176	23·3
6	·79	173	22·9	180	23·8	187	24·7	169	22·4	176	23·3	183	24·2
6½	·86	188	24·8	195	25·8	202	26·8	184	24·4	191	25·3	198	26·2
7	·93	203	26·9	210	27·8	217	28·7	193	25·5	206	27·3	213	28·2
7½	·99	218	28·9	225	29·8	232	30·7	214	28·3	221	29·2	228	30·2
8	1·06	233	30·8	240	31·8	247	32·7	228	30·2	235	31	242	32
8½	1·12	248	32·8	255	33·7	262	34·7	243	32·1	·250	33	257	34
9	1·19	263	34·8	270	35·7	285	37·7	258	34·1	265	35	280	37
10	1·3	286	37·8	300	39·7	315	40·7	281	37·2	294	38·9	309	39·9
11	1·46	316	41·8	330	43·7	345	45·6	310	41	324	42·9	339	44·8

Quality Thickness m/m.	oz.	Standard weights. Min. m/m.	Min. oz.	Av. m/m.	Av. oz.	Max. m/m.	Max. oz.	2% lighter weights. Min. m/m.	Min. oz.	Av. m/m.	Av. oz.	Max. m/m.	Max. oz.
12	1·59	346	45·8	360	47·6	375	49·6	340	45	353	46·7	368	48·7
13	1·72	376	49·7	390	51·6	405	53	369	48·7	382	50·5	397	52·5
14	1·85	406	53·7	420	55·6	435	57·6	398	52·6	412	54·5	427	56·5
15	1·98	436	57·7	450	59·5	465	61·5	428	56·6	441	58·3	456	60·3
16	2·11	466	61·7	480	63·5	495	65·5	457	60·5	470	62·2	585	64·2
17	2·25	496	65·6	510	67·5	525	69·5	486	64·3	500	66·2	515	68·1
18	2·38	526	69·9	540	71·4	555	73·4	516	68·3	529	70	544	72
19	2·51	556	73·6	570	75·4	585	77·4	545	72·1	559	74	573	75·9
20	2·65	586	77·5	600	79·4	615	81·4	574	76	588	77·8	603	79·8

Weight Table.

27″ × 50 yds.

Denoting in "momme" and in corresponding ounces the approximate weight of Japanese silk piecegoods per piece together with tolerable limits for maximum and minimum weights.

Quality Thickness m/m	oz.	Standard weight. Min. m/m	Min. oz.	Av. m/m	Av. oz.	Max. m/m	Max. oz.	2% lighter weights. Min. m/m	Min. oz.	Av. m/m	Av. oz.	Max. m/m	Max. oz.
2¼	·33	81	10·71	90	11·90	99	13·09	79	10·45	88	11·64	97	12·83
2¾	·36	90	11·90	99	13·09	108	14·28	88	11·64	97	12·83	106	14·03
3	·39	99	13·09	108	14·28	117	15·47	97	12·83	106	14·03	115	15·22
3¼	·43	108	14·28	117	15·47	126	16·66	106	14·03	115	15·22	124	16·41
3½	·46	117	15·47	126	16·66	135	17·86	114	15·09	123	16·28	132	17·47
3¾	·5	126	16·66	135	17·86	144	19·05	123	16·28	132	17·47	141	18·66
4	·53	135	17·86	144	19·05	153	20·24	132	17·47	141	18·66	150	19·85
4¼	·56	144	19·05	153	20·24	162	21·43	141	18·66	150	19·85	159	21·04
4½	·6	153	20·24	162	21·43	171	22·62	150	19·85	159	21·04	168	22·23
4¾	·63	162	21·43	171	22·62	180	23·81	159	21·04	168	22·23	177	23·42
5	·66	171	22·62	180	23·81	189	25·01	167	22·10	176	23·29	187	24·48
5¼	·7	180	23·81	189	25·01	198	26·20	176	23·29	185	24·48	194	25·67
5½	·73	189	25·01	198	26·20	207	27·38	185	24·48	194	25·67	203	26·86
5¾	·76	198	26·20	207	27·38	216	28·57	194	25·67	203	26·86	212	28·05
6	·79	207	27·38	216	28·57	225	29·76	203	26·86	212	28·05	221	29·24
6½	·86	225	29·76	234	30·96	243	32·14	220	29·11	229	30·30	238	31·49
7	·93	243	32·14	252	33·35	261	34·53	238	31·49	247	32·68	256	33·87
7½	·99	261	34·53	270	35·72	279	36·81	256	33·87	265	35·06	274	36·25
8	1·06	279	36·81	288	38·10	297	39·29	273	36·11	282	37·30	291	38·49
8½	1·12	297	39·29	306	40·49	315	41·67	291	38·49	300	39·68	309	40·87
9	1·19	316	41·79	324	42·86	342	45·24	310	41·01	318	42·07	335	44·32
10	1·3	343	45·37	360	47·62	378	50·01	336	44·45	353	46·70	370	48·94
11	1·46	379	50·14	396	52·39	414	54·77	371	49·08	388	51·33	406	53·71
12	1·59	415	54·90	432	57·15	450	59·53	407	53·85	423	55·96	441	58·34
13	1·72	451	59·66	468	61·91	486	64·29	442	58·47	459	60·72	476	62·97
14	1·85	487	64·43	504	66·67	522	69·01	477	63·10	494	65·35	512	67·63
15	1·98	523	69·14	540	71·44	558	73·82	513	67·76	529	69·99	547	72·36
16	2·11	559	73·95	576	76·20	594	78·58	548	72·49	564	74·61	582	76·99
17	2·25	595	78·71	612	80·96	630	83·34	583	77·13	600	79·38	617	81·63
18	2·38	631	83·47	648	85·73	666	88·11	618	81·76	636	84·14	653	86·39
19	2·51	667	88·24	684	90·49	702	92·87	654	86·52	670	88·63	688	91·02
20	2·65	703	93	720	95·25	738	97·63	689	91·15	706	93·40	723	95·64

WEIGHT TABLE (33″ and 40″ × 50 yds.)

Denoting in "momme" and in corresponding ounces the approximate weight of Japanese silk piecesgoods per piece together with tolerable limits for minimum and maximum weights.

Quality Thickness m/m	oz.	33″ × 50 yds. Standard weight Min. m/m	Min. oz.	Av. m/m	Av. oz.	Max. m/m	Max. oz.	Quality m/m	oz.	40″ × 50 yds. Standard weight Min. m/m	Min. oz.	Av. m/m	Av. oz.	Max. m/m	Max. oz.
4	·53	154	20·4	176	23·3	198	26·2	4	·53	194	25·7	214	28·3	234	31
4½	·6	176	23·3	198	26·2	220	29·1	4½	·6	220	29·1	240	31·8	260	34·4
5	·66	198	26·2	220	29·1	242	32	5	·66	247	32·7	267	35·3	287	38
5½	·73	220	29·1	242	32	264	35	5½	·73	274	36·3	294	38·9	314	41·5
6	·79	242	32	264	35	286	37·8	6	·79	294	38·9	320	42·3	346	45·8
6½	·86	264	35	286	37·8	308	40·8	6½	·86	321	42·5	347	46	373	49·3
7	·93	286	37·8	308	40·8	330	43·2	7	·93	348	46	374	49·5	400	53
7½	·99	308	40·8	330	43·2	352	46·6	7½	·99	375	49·6	401	53	427	56·8
8	1·06	330	43·2	352	46·6	374	49·5	8	1·06	401	53	427	56·5	453	60
9	1·19	374	49·5	396	52·4	418	55·3	9	1·19	455	60·2	481	63·7	507	67
10	1·3	418	55·3	440	58·2	462	61·1	10	1·3	508	67·2	534	70	560	74
11	1·46	462	61·1	484	64	506	67	11	1·46	561	74·2	584	77·3	618	81·8
12	1·59	500	66·2	528	69·9	558	73·8	12	1·59	615	81·4	641	84·8	667	88·2
13	1·72	550	72·8	572	76	594	78·6	13	1·72	668	88·4	694	91·8	720	95·3
14	1·85	594	78·6	616	81·4	638	84·4	14	1·85	722	95·5	748	99	774	102·4
15	1·98	638	84·4	660	87·3	682	90·2	15	1·98	775	102·5	801	106	827	109·4
16	2·11	682	90·2	704	93·2	726	96	16	2·11	828	109·5	854	113	880	116·4
17	2·25	726	96	748	99	770	101·8	17	2·25	882	116·7	908	120·1	934	123·6
18	2·38	770	101·8	792	104·8	814	107·7	18	2·38	935	123·7	961	127·2	984	130·2
19	2·51	814	107·7	836	123·8	858	126·8	19	2·51	989	130·8	1015	134·3	1041	137·7
20	2·65	858	113·5	880	116·4	902	119·3	20	2·65	1042	137·9	1068	141·3	1094	144·7

WEIGHT TABLE (36″ × 50 yds.)

Denoting in "momme" and in corresponding ounces the approximate weight of Japanese silk piecegoods per piece together with tolerable limits for maximum and minimum weights.

Quality Thickness m/m	oz.	Standard weights. Min. m/m	Min. oz.	Av. m/m	Av. oz.	Max. m/m	Max. oz.	2% lighter weights. Min. m/m	Min. oz.	Av. m/m	Av. oz.	Max. m/m	Max. oz.
2½	·33	108	14·3	120	15·9	132	17·5	106	14	118	15·6	129	17
2¾	·36	120	15·9	132	17·5	144	19	118	15·6	129	17	141	18·7
3	·39	132	17·5	144	19	156	20·6	129	17	141	18·7	153	20·3
3¼	·43	144	19	156	20·6	168	22·2	141	18·7	153	20·3	165	21·8
3½	·46	156	20·6	168	22·2	180	23·8	153	20·3	165	21·8	176	23·3
3¾	·5	168	22·2	180	23·8	192	25·4	165	21·8	176	23·3	188	24·9
4	·53	180	23·8	192	25·4	204	27	176	23·3	188	24·9	200	26·5
4¼	·56	192	25·4	204	27	216	28·6	188	24·9	200	26·5	212	28
4½	·6	204	27	216	28·6	228	30·2	200	26·5	212	28	224	29·6
4¾	·63	216	28·6	228	30·2	240	31·8	211	27·9	223	29·5	235	31
5	·66	228	30·2	240	31·8	252	33·3	223	29·5	235	31	247	32·7
5¼	·7	240	31·8	252	33·3	264	35	235	31	247	32·7	259	34·3
5½	·73	252	33·3	264	35	276	36·5	247	32·7	259	34·3	271	35·9
5¾	·76	264	35	276	36·5	288	38·1	259	34·3	270	35·7	282	37·3
6	·79	276	36·5	288	38·1	300	39·7	270	35·7	282	37·3	294	38·9
6½	·86	300	39·7	312	41·3	324	42·9	294	38·9	306	40·5	318	42
7	·93	324	42·9	336	44·5	348	46	317	41·9	329	43	341	45·1
7½	·99	348	46	360	46·6	372	49·2	341	45·1	353	46·7	365	48·3
8	1·06	372	49·2	384	50·8	396	52·4	364	48·2	376	49·8	388	51·3
8½	1·12	396	52·4	408	54	420	55·6	388	51·3	400	53	412	54·5
9	1·19	421	55·7	432	57·2	456	60·3	411	55·4	423	56	447	59·1
10	1·3	459	60·5	480	63·6	504	66·7	448	59·3	470	62·2	494	65·4

Quality Thickness m/m	oz.	Standard weights. Min. m/m	Min. oz.	Av. m/m	Av. oz.	Max. m/m	Max. oz.	2% lighter weights. Min. m/m	Min. oz.	Av. m/m	Av. oz.	Max. m/m	Max. oz.
11	1·46	505	66·8	528	69·9	552	70	495	65·5	517	68·4	541	71·6
12	1·59	553	70·2	576	76·2	600	79·4	542	71·7	564	74·6	588	77·8
13	1·72	601	79·5	624	82·6	648	85·7	589	77·9	611	80·8	635	84
14	1·85	649	85·9	672	88·9	696	92	636	84·1	659	87·2	682	90
15	1·98	697	92·2	720	95·3	744	98·4	683	90·4	706	93·4	729	96·4
16	2·11	745	98·6	768	101·5	792	104·8	730	96·6	753	99·6	776	102·7
17	2·25	793	105	816	108	840	111·1	777	102·8	800	105·8	823	108·9
18	2·38	841	111·3	864	114·3	888	117·5	824	109	847	112	870	115
19	2·51	889	117·6	912	120·7	936	123·8	871	115·2	894	118·3	917	121·3
20	2·65	937	124	960	127·1	984	130·2	918	121·4	941	124·5	964	127·5

WEIGHT TABLE (45″ × 50 yds.)

Denoting in "momme" and in corresponding ounces the approximate weight of Japanese silk piecegoods per piece together with tolerable limits for minimum and maximum weights.

Quality Thickness m/m	oz.	Standard weights. Min. m/m	Min. oz.	Av. m/m	Av. oz.	Max. m/m	Max. oz.
4	·53	215	28·4	240	31·8	265	35
4½	·6	245	32·4	270	35·7	295	39
5	·66	275	36·4	300	39·7	325	43
5½	·73	305	40·4	330	43·7	355	47
6	·79	330	43·7	360	47·6	390	51·6
6½	·86	360	47·6	390	51·6	420	65·6
7	·93	390	51·6	420	65·6	450	69·5
7½	·99	420	65·6	450	69·5	480	73·5
8	1·06	450	69·5	480	73·5	510	67·4
9	1·19	511	67·5	540	71·4	570	75·7
10	1·3	571	75·8	600	79·4	630	83·3
11	1·46	631	83·5	660	87·3	696	92
12	1·59	691	90·9	720	95·3	750	99·2
13	1·72	751	99·3	780	103·2	810	107·2
14	1·85	811	107·3	840	111·1	870	115
15	1·98	871	115·2	900	119	930	123
16	2·11	931	123·2	960	127·1	990	131
17	2·25	991	130·1	1020	135	1060	140·2
18	2·38	1061	140·4	1080	142·9	1110	146·9
19	2·51	1111	147	1140	150·8	1170	154·8
20	2·65	1171	135	1200	158·8	1230	162·7

Weight Table (23″ × 60 yds.)

Denoting in "momme" and in corresponding ounces the approximate weight of silk fabrics per piece together with tolerable limits for maximum and minimum weights.

Quality. Thickness m/m	oz.	Standard weights. Min. m/m	Min. oz.	Av. m/m	Av. oz.	Max. m/m	Max. oz.	2% lighter weights. Min. m/m	Min. oz.	Av. m/m	Av. oz.	Max. m/m	Max. oz.
9	1·19	315	41·7	324	42·9	342	45·2	309	40·9	318	42	335	44·3
10	1·3	343	45·4	360	47·6	378	50	336	44·5	353	46·7	370	49
11	1·46	379	50·1	396	52·4	414	54·8	371	49	388	51·3	406	53·7
12	1·59	415	54·9	432	57·2	450	59·5	407	53·9	423	56	441	58·3
13	1·72	451	59·7	468	61·9	486	64·3	442	58·5	459	65·4	476	63
14	1·85	487	64·4	504	66·7	522	69	447	63·1	494	65·4	512	67·6
15	1·98	523	69·1	540	71·4	558	73·8	513	67·8	529	70	547	72·4
16	2·11	559	74	576	76·2	594	78·6	548	72·5	564	74·6	582	77
17	2·25	595	78·7	612	81	630	83·3	583	77·1	600	79·4	617	81·6
18	2·38	631	83·5	648	85·7	666	88·1	618	81·8	636	84·1	653	86·4
19	2·51	667	88·2	684	90·5	702	92·9	654	86·5	670	88·6	688	91
20	2·65	703	93	720	95·3	738	97·6	689	91·2	706	93·4	723	95·6

Weight Table (27″ × 60 yds.)

Denoting in "momme" and in corresponding ounces the approximate weight of silk piecegoods per piece together with tolerable limits for maximum and minimum weights.

Quality Thickness m/m	oz.	Standard weights. Min. m/m	Min. oz.	Av. m/m	Av. oz.	Max. m/m	Max. oz.	2% light weights. Min. m/m	Min. oz.	Av. m/m	Av. oz.	Max. m/m	Max. oz.
9	1·19	378	50	389	51·5	410	54·2	370	49	381	50·4	402	53·2
10	1·3	411	54·4	432	57·2	454	60	403	53·3	424	56·1	445	58·9
11	1·46	455	60·2	475	62·8	497	65·2	446	59	466	61·7	487	64·4
12	1·59	498	65·4	518	68·5	541	71·6	488	64·6	508	67·2	529	70
13	1·72	542	71·7	562	74·5	583	77·1	530	70·1	550	72·8	572	75·7
14	1·85	584	77·3	605	80	626	82·8	573	75·8	593	78·5	614	81·2
15	1·98	627	83	648	85·7	670	88·6	613	81·4	635	84	656	86·8
16	2·11	671	88·8	691	91·4	713	94·3	657	87	677	89·6	699	92·5
17	2·25	714	94·5	734	97·1	766	101·3	700	92·6	720	95·3	741	98
18	2·38	767	101·5	778	103	799	105·7	742	98·2	762	100·8	783	103·6
19	2·51	800	106·6	821	108·6	842	111·4	784	103·7	804	106·4	826	109·3
20	2·65.	843	111·5	864	114·3	887	117·4	827	109·4	847	112	869	115

Weight Table (32″ × 60 yds.)

Denoting in "momme" and in corresponding ounces the approximate weight of Japanese silk piecegoods per piece together with tolerable limits for maximum and minimum weights.

Quality Thickness m/m	oz.	Standard weights. Min. m/m	Min. oz.	Av. m/m	Av. oz.	Max. m/m	Max. oz.	2% lighter weights. Min. m/m	Min. oz.	Av. m/m	Av. oz.	Max. m/m	Max. oz.
18	2·4	896	118·5	922	122	947	125·3	891	117·9	904	119·6	929	123
19	2·5	948	125·4	978	129·4	998	132	929	123	954	126·2	979	129·5
20	2·7	999	132·3	1024	135·5	1050	139	980	129·7	1004	132·8	1030	136·3
21	2·8	1051	139	1075	142·2	1101	145·7	1031	136·4	1054	139·4	1079	142·8
22	2·9	1102	145·8	1125	148·8	1152	152·4	1080	142·9	1103	146	1129	149·4
23	3	1153	153·2	1178	155·9	1203	159·2	1130	149·5	1154	152·7	1179	156
24	3·2	1204	159·3	1229	162·6	1254	166	1180	156·1	1204	159·3	1229	162·6
25	3·3	1255	166	1280	169·3	1306	172·8	1230	162·7	1254	166	1279	169·2
26	3·4	1307	173	1331	176	1357	179·5	1280	169·3	1304	172·5	1329	175·8

WEIGHT TABLE (36″ × 60 yds.)

Denoting in "momme" and in corresponding ounces the approximate weight of Japanese silk piecegoods per piece together with tolerable limits for maximum and minimum weights.

Quality Thickness m/m	oz.	Standard weights. Min. m/m	Av. oz.	Av. m/m	Av. oz.	Max. m/m	Max. oz.	2% lighter weights. Min. m/m	Min. oz.	Av. m/m	Av. oz.	Max. m/m	Max. oz.
9	1·19	504	66·7	518	68·5	547	72·4	494	65·4	508	67·2	536	70·9
10	1·3	548	72·5	576	76·2	605	80	537	71	564	74·6	592	78·3
11	1·46	606	80·1	633	83·7	662	87·6	593	78·5	620	82	647	85·7
12	1·59	663	87·8	691	91·4	720	95·3	650	86	677	89·6	706	93·6
13	1·72	721	95·4	749	99	778	103	707	93·5	734	97·1	762	100·8
14	1·85	779	103·1	806	106·6	835	110·5	763	101	790	104·5	819	108·4
15	1·98	836	110·6	864	114·3	893	118·1	820	108·5	847	112	876	115·9
16	2·11	894	118·3	922	122	950	125·7	877	116	903	119·5	931	123·1
17	2·25	951	125·8	979	129·5	1008	133·4	932	123·3	960	127	988	130·7
18	2·38	1009	133·5	1037	137·2	1066	141	989	130·8	1016	134·4	1044	138·1
19	2·51	1067	141·2	1094	144·7	1123	148·6	1045	138·3	1073	142	1101	145·7
20	2·65	1124	148·7	1152	152·4	1181	156·3	1102	145·8	1129	149·4	1157	153
21	2·78	1182	156·4	1210	160	1238	163·8	1158	153·2	1185	156·8	1214	160·6
22	2·9	1239	163·9	1267	167·6	1296	171·5	1215	160·7	1242	164·3	1270	168
23	3	1297	171·6	1324	175·2	1354	179·1	1271	168·2	1298	171·7	1327	175·6
24	3·18	1355	179·3	1382	182·8	1411	186·7	1328	175·7	1355	179·3	1383	183
25	3·31	1412	186·8	1440	190·5	1469	194·3	1384	183·1	1411	186·7	1440	190·5
26	3·44	1470	194·5	1498	198·2	1526	101·9	1441	190·6	1468	194·2	1491	197·3

117. Conditioning or inspection of export fabrics in Japan.

The Government passed a law for the control for export silk fabrics (Law No. 27 of 1927 which came into force on 15th January, 1928) and the Department of Commerce and Industry under Ordinance No. 12 of 1927 issued detailed regulations for the enforcement of this law.

The law is given in Appendix I.

1. The regulations under this law provide that "export silk fabric" shall mean and include all fabrics for export woven with silk yarn or with silk yarn mixed with other yarn but having more than one-third of warp and weft in silk and the fabrics more than 18 inches in width and more than 12½ yards in length.

"Silk yarn" shall mean and include pure silk yarn, *fushi-ito* (dupion silk), spun silk, wild silk yarn or wild spun silk. "Export pure silk fabric" shall mean and include all *habutae*, satin, *usu-ginu shike-ginu*, crepe, *kabe*, *pongee* and *fuji-ginu*. "Export gloss silk fabric" shall mean and include fabrics woven with refined i.e. degummed silk yarn or dupion yarn.

2. Pure and gloss silk fabrics shall not be exported for business unless they have passed inspection in the Japanese Imperial Government Silk Conditioning, (i.e. Inspection) Houses. The following classes of fabrics are exempted :—

(1) Fabrics weighted with tin salts.

(2) Fabrics dyed.

(3) Continuous fabrics for handkerchiefs and mufflers.

(4) *Pongee* fabric woven with spun silk from cocoons other than wild silk cocoons.

(5) *Fuji ginu*, woven with spun silk from cocoons other than domestic, i.e. mulberry cocoons.

3. Inspection shall be made to determine the following, viz :—

I. Quality on the basis of :—

(a) Yarn and work on yarn.
(b) Texture.
(c) Weaving.
(d) Degumming, bleaching and finishing.

II. Weight in thoroughly dried condition after degumming.

III. Length between two ends and width omitting one of the selvages.

IV. Defects, stains or "do-gire" (joint breaks).

V. Other items which are indispensable in determining quality and necessary to be considered in passing a piece.

4. "Export pure silk fabrics" must conform to the following specifications for being fit to be passed. The specifications below are given in full as giving an indication of fabrics in demand in the world's markets.

Class of fabric.	Materials used in manufacture.	No. of warp (WP) and weft (WT) threads.	Within 6 inch ends.	picks.	*Mome-zuke* not less than the first or over second figure.	
Plain *habutae* and satin	Raw silk or dupion silk	1 wp. × 1 wt.	75	50—70	3—6·5	
		1 wp. × 2 wts.	75	55—65	5—6·5	
		2 wps. × 1 wt.	75	60—65	6	
		2 wps. × 2 wts.	75	50—60	6·5—8	
Twill *habutae*	,,	1 wp. × 1 wt.	75	60—65	5	
		1 wp. × 2 wts.	75	55—60	5	
		2 wps. × 1 wt.	75	60—65	7	
		2 wps. × 2 wts.	75	55 × 65	6—7	
Bocaded *habutae*	,,	...	70—75	40—70	10	
Usu-ginu	,,	...	60—65	40—45	2¼	
Shike-ginu brocaded	,,	1 wp. × 1 wt.	65	36	6	
		1 wp. × 2 wts.	65	36	6	
		2 wps. × 1 wt.	65	36	6	
		2 wps. × 2 wts.	65	34	6	
Other	,,	...	65	40	...	
Crepe, Georgette	Raw silk	...	50—60	50—60	6—8	Exceptions—
			85—80	45—50	7—12	Twilled, brocaded
Other	,,	...	75	45—50	6—12	and fairy fabrics.
Kabe	,,					
Pongee	Wild raw or wild spun silk	1 wp. × 1 wt.	58	52	11	
		1 wp. × 2 wts.	58	48	11	
		2 wps. × 2 wts.	46	40—42	13—15	Exceptions :—
		3 wps. × 3 wts.	46	36—38	15	Twilled, brocaded
		2 wps. × 4 wts.	46	32	15	and special weaves.
		3 wps. × 2 wts.	38	42	15	
		3 wps. × 3 wts.	38	36—38	15	
		3 wps. × 4 wts.	38	32	15	
Fuji-ginu	Spun silk	2 wp.	50—62	40—47	17—19	Exceptions :—
		1 wp.	63—78	40—47	17—19	Brocades and other special weaves.

There are regulations that certain high grades and qualities of raw and spun silk must be used in order that the goods may be classed as I.

5. *Export gloss silk fabrics* are to conform to the following specifications :—

Class of fabric.	Materials used in manufacture	No. of warps and wefts.	No. in ·5 bu or ·6 inch of ends.	picks	M/m when finished	Remarks
Taffeta plain	Degummed and twisted yarn in warp and degummed yarn in weft.	3 or up wps. × 1 or 2 wts.	120 up	58 up for single, 46 up for double wefts.	9·5—17	
		3 or up wps. × 1 or 2 wts.	132 up	—Do.—	11·5—17	
Satin	,,	3 or up wps. × 1 or 2 wts.	120 up	60 up for single, 56 up for double wefts.	9·5—17	
Hon Kaiki plain	,,	2 wps. × 1 or 2 wts.	80—88	52 up for single, and 48 up for double wefts.	9·5—12·5	
Tana Kaiki plain	Degummed and twisted yarn or dupion in warp and degummed or half-degummed dupion in weft.	2 wps.	80—88	48 up	9·5—12·5	
Kata Kaiki plain	Degummed or half-degummed half-twisted silk yarn in warp and degummed or half-degummed silk in weft.	2 wps.	56—64	48 up	5·5—8·5	

6. No wetting or weighting with magnesium chloride, tin salt, sugar or earth is permissible for pure export silk fabrics. Tin salts are allowed for crepes and dyed fabrics but with a proper record which has to be maintained for three years and with proper indications on the fabrics treated. In the case of gloss silk fabrics use of starch necessary for weaving or finishing up to about 5 per cent of the weight of the fabric before finishing is permitted.

7. Refining or finishing and dyeing of export fabrics are regulated in factories which can be started and worked with the permission of the Minister for Commerce and Industry. Details of machinery, equipment and building, methods of work, maintenance of records, etc. have to be approved.

8. Stamps are prescribed to be used for "passed", "rejected", length, width, weight, defects, stain, "end", etc.

118. Manufacturing processes of fabrics woven with raw silk in India.

A. *Classification of fabrics* :—Fabrics from raw silk can be classified as follows as regards method of manufacture.

Class I.— Woven with raw silk untwisted.

Class II.— Woven with raw silk twisted.

Class III.— Woven with silk degummed and twisted and also when dyed for patterns and colour effects.

As regards weave or texture and patterns of weaving :—

(a) The major portion of the fabrics is woven plain on two shaft looms. Patterns are effected with coloured warp and weft threads.

(b) Twill is woven on four shaft looms and also variations possible with four shafts. Pattern effect is produced with the use of coloured warp and weft threads.

(c) Borders of *sarees*, *dhotis*, *chadars*, etc., which usually have a plain ground are either solid in uniform colour or patterned with coloured threads in plain weaves or figured with various designs with coloured silk and gold and silver threads with the help of Dobbie and Jacquard attachments to the looms. Without these special attachments similar effects are produced by heald combinations brought about by the pulling of cords attached to the healds and by the use of wedges to hold the pulled up warps.

(d) Brocades are woven on hand-looms with elaborate arrangement of loops of cords attached to heald combinations, the loops being pulled by a drawboy. Coloured silk and gold and silver threads are used to bring out and ornament the designs.

(e) Patterns and figure effects are also brought about with the help of only dyes on woven fabrics.

(1) Colours are printed on the fabrics :—

(i) with hand blocks on which designs are carved ;

(ii) with the colours sprayed on the fabrics ;

(iii) with the colours applied on the fabrics through screens or stencilled patterns.

(2) Warp threads are tied tightly at intervals and dyed, the untied parts taking the colours and then arranged in patterns.

(3) The woven fabric is similarly tied and dyed.

(f) Patterns are produced by embroidery with coloured silk and gold and silver threads on the fabric.

Fabrics of class I are woven with untwisted raw silk.

Raw silk reeled fine uniformly to a particular thickness or denier, i.e. good graded filature or denier silk can be at once prepared for weaving without any processing and is so prepared for *korahs* of Bengal, *habutae* of Japan and similar fabrics. The woven fabrics are then degummed by being boiled with soap and finished for the market or utilised for printed fabrics.

The *charkha* silk of Mysore and Madras, *khungru* silk, *tana* and *bharna* of Bengal, Bangkok and ordinary Chinese, Canton and other silks, dupions of Japan and Kashmir and all raw silks reeled coarse are first of all sorted out according to thickness. The process is known as *firan* or winding off and sorting is carried out by the womenfolk of the weavers themselves with the help of simple swifts and bamboo hand reels. The thread is passed from swift to hand reel through the fingers and sorting is carried out by the feel of the fingers aided by the eye. The different thicknesses are wound on different hand reels. The good uniform portion goes to make the warp and the rest is used for the weft. The *tana* (i.e. warp) thread of Bengal is reeled with special care for use in the warp. What is reeled as *bharna* (i.e. weft) cannot be used as *tana*. Both require to be processed in the manner described, wound off and sorted.

Fabrics of class II, better and stronger than class I, *sarees*, *dhoties*, *chadars* etc., are woven with twisted raw silk in the warp untwisted raw silk being used in the weft. For preparing the warp thread usually two untwisted threads are run together and twisted. For the weft two or three untwisted threads are run together and used in untwisted condition. Twisting is done after the first process of *firan* described under I above. The twisted yarn as well as the fabrics woven with it are described as *pakwan*. The indigenous methods of producing *pakwan* yarn are described below.

In the improved method warp thread is prepared on power machinery by first of all twisting the single threads from right to left about six turns per inch and then running together two or three or as many twisted threads as desired and twisting them in the reverse direction into one yarn. Such warp is described as *organzine*. Weft yarn is usually prepared by giving two or more untwisted threads a looser twist of about three turns per inch such weft is known as *tram*.

Crepes are fabrics woven with very highly twisted raw silk both in the warp and weft. Such high twists are not capable of being given in the indigenous methods of twisting and can be carried out only on power machinery.

The process of twisting, doubling, etc., carried out with machinery is technically described as *throwing*, the machinery used as *throwing machinery* and the twisted yarn produced as *thrown yarn*, corresponding to *pakwan* in the indigenous methods. Raw silk after it has been thus processed is known as thrown yarn.

Fabrics of class III woven with twisted and degummed silk are still better and stronger, such as *thans*, suitings and shirtings, etc.

In one process the raw silk in the hanks is degummed and then dried and twisted into yarn which is then woven. Dyeing when necessary is carried out at the time of degumming.

The better method is to twist or throw the raw silk and then degum and dye it and then weave it. This is the practice in organised weaving.

B. *Processing of raw silk.*

Processing before weaving has to be carried out and varied according to the kind and class of fabrics desired as briefly described above. Processing involves the following operations in order.

1. Winding (raw) sometimes called rereeling ...	From hank to bobbin (from hank to hand reels in the indigenous methods).
2. Doubling ...	Two or more threads are combined to form one thread. This is done in throwing machinery from as many bobbin as are required to be doubled to one bobbin and in the indigenous methods from swifts to hand reels.
3. Twisting (sometimes technically described as throwing)	This is done from bobbin to bobbin in the throwing machinery. Twisting in the indigenous methods is described below.
4. Steaming ...	The twisted yarn is exposed to steam on the bobbins to set the twist.
5. Hanking ...	The twisted yarn from the bobbins is made into hanks.
6. Degumming technically known as boiling-off ...	The twisted hanks are boiled with soap or soap and a little soda to remove the natural gum. The degummed hanks are dried either in the sun or in drying chambers.
7. Winding soft ...	The degummed yarn—from the hanks to bobbins.

The above describes the general sequence of operations. Frequently the following additional operations are practised.

Soaking before winding :—The raw silk hanks are soaked before winding in cold water with an oil and soap dissolved in it. The hanks are soaked overnight, the water lightly wrung out and the hanks left on a raised table or platform to dry partly. Soaked raw silk

becomes easier to be processed in the throwing machinery than when unsoaked. *Second winding* in the raw after the first winding, frequently is called cleaning from bobbin to bobbin. In some form of machinery the thread passes between the edges of two flat metal or glass knives set vertically and adjustable according to the thickness of the thread. Wastes, slugs, etc., adhering to the thread are caught up and removed. The second winding also helps to give a stretch to the thread desirable when the raw silk is intended to be used in the warp for weaving in the raw.

Twisting in the single :—For high class goods or hosiery each thread is twisted from right to left and the twisted threads are then doubled and twisted together in the reverse direction in the way ropes are manufactured.

For weaving thick pieces for use in suitings or manufacturing articles in which thick degummed yarns are required to be used, for instance, cords of parachutes, further doubling and twisting may be necessary after process No. 7 described above.

Combination of processing operations :—Frequently doubling and twisting are combined. Machinery has been devised to carry out doubling and twisting of the doubled yarn in one operation. Sometimes twisting of the doubled yarn and hanking are carried out on the same machine in one operation.

Dyeing :—Dyeing is done either of the raw silk or yarn for pattern weaving or of whole pieces. When in the case of *sarees* the entire ground is coloured with designs in the borders or ends, the entire yarn used in the fabric has to be dyed.

C. *Twisting or throwing of raw silk according to the indigenous methods.*

Old indigenous methods are still followed by the silk weavers in the different silk weaving centres in India and the implements used are often of simple types which are in various stages of evolution and necessarily with various degrees of efficiency.

(1) The simplest appliances and methods are used in Bengal, Benares and Assam. A professional twister, *chambalia*, works with the help of a boy. He erects two bamboo posts vertically about 6 ft. apart and ties two cross slips at a height of about 6 ft. from the ground. This forms one support and such supports are erected at intervals along a straight road or in an open place in a straight line to a distance calculated according to output. The cross slips are devided into 10 compartments by vertical slips tied on them. The doubled thread to be twisted is passed from the end where the twisters sit usually under a shade to the other end through compartment 1 and brought back through compartment 2. Similarly threads are arranged in the other compartments. The ten free ends are broken and small *takus* (spindles) are attached to them and kept turning with the fingers thus giving twists to the thread. Twisting is taken to be complete when the ends shorten by about 3 ft. Now a fresh thread is tied to the end in compartment 1 and the end in compartment 2 is tied to a hand bamboo reel (*latai*) and pulled in and wound on the *latai*. Fresh threads are fitted into all the compartments in this manner and twisting continued. There is no machine used in this method. Any method using a machine is better. But costly *sarees* of Benares and other places have continued to be produced with yarn twisted in this manner.

(2) The simplest machine used in twisting is made on the principle of the ordinary spinning wheel or *charkha*, a large wheel turning the iron spindle by a belt. A reed containing the thread is fitted on the spindle and the thread is slowly drawn off the reed, receives the twist and is wound on a small reel on the axle of the wheel. Usually several spindles are thus worked each with a separate belt from the wheel. This is the system followed in Nagpur, Belgaum, Poona, etc.

(3) The above is modified in the Punjab. The big wheel turns a number of spindles by a single belt passing successively round opposite sides of them and the small reels receiving ths twisted silk are turned by belt from the axle of the wheel.

(4) In Burma the machine made on similar principle is pedal driven with an oscillating bar to lay the twisted silk on the receiving reel in criss-cross arrangement. In Kumbakonam the receving reel itself moves up and down for criss-cross arrangement of the twisted yarn received on it.

(5) The Surat twisting machine is copied from the power machine and is hand driven. The vertical spindles on both sides are turned each by a separate belt from the horizontal drum turned by the operator. Other belts from the axle of the drum drive the baby reels on both sides on top of the spindles, each reel receiving the twisted yarn from its corresponding spindle.

D. *Throwing with power machinery.*

The operations in the processing of the raw silk described above are very satisfactorily and quickly performed on power-driven throwing machinery. The thrown yarn produced is much better and more standardised than in the indigenous methods. This is why thrown-yarn is imported from Japan and also from China and used on a large scale in Benares and other important weaving centres such as Burma. There is scope for throwing of silk yarn being carried out as an industry by itself.

In Japan throwing mills often combine dyeing and warping and export-prepared warps.

Silk weaving mills in India as a rule have their own throwing machinery. The rayon mills lately established for obvious reasons have no throwing plant.

E. *Preparatory operations for weaving.*

1. *Calculations* :—According to the length, width and weave of the fabric desired to be woven and the thickness of the yarn to be used the following calculations have first to be made viz. :—

(i) Length of the warp to be taken. The practice is to prepare as long warps as possible 100, 200 or 300 yards and weave out several pieces of fabrics with this warp. About 6 per cent has to be allowed for contraction in the finished piece for the warp.

(ii) The total width of the warp to be taken and the number of the warp threads called ends per inch of this width. An allowance has to be made for contraction of about $7\frac{1}{2}$ per cent in the finished fabric for the weft.

(iii) The number of weft threads, called picks, to be put in per inch.

(iv) The quantity of yarn to be used in the warp and weft.

Example :—Say a fabric of the following specifications is desired to be woven viz. plain piece 50 yards in length and 36 inches in width weighing 1·6 oz. per sq. yds. i.e. 12 m/m. quality with a tensile strength of not less than 40 lbs. per inch both ways.

The raw silk to be used indicates the following qualities on the result of test in the Conditioning House.

Average denier	...	21
Breaking strength	...	3·4 grammes per denier.
Degumming loss	...	22 per cent.

For the piece the length of the warp should be 53 yards and its width 39 inches. This warp will give a finished piece, 50 yds. × 36 inches and its weight will be $50 \times 1{\cdot}6 = 80$ oz.

Therefore the weight of the warp in the raw is calculated :—

53 yds. × 39 inches finished is 80 oz. ; add 3% weaving waste $=82\frac{1}{2}$ oz. ; add 22% boil-off loss on 82·5 oz. $=80+2\frac{1}{2}+18=100\frac{1}{2}$ oz.

As the texture is to be similar both ways half of this weight is to be used in warp and half in weft i.e. $50\frac{1}{4}$ oz. in each.

A lb. of one denier raw silk measures 44,64,528 yds.

The total length of all warp threads is therefore $\frac{44{,}64{,}258}{21} \times \frac{50{\cdot}25}{16}$ yards=6,67,686 yds. which has to be accommodated in a space of 39 inches in 53 yd. lengths.

The number of 53 yd. lengths=12,598.

∴ per inch of warp (12,598 ÷ 39)=324 lengths.

With a reed having 54 dents per inch 6 threads are to be put in a dent. Therefore the warp yarn is to be 3 fold.

The number of picks to be given can be determined in the following manner :—

A total of 6,67,686 yards has to be accommodated in the same space (53 yds. × 39 inches) in lengths of 39 inches each.

Total number of 39 inch lengths= $\frac{6,67,686}{39} \times 36 = 6,16,326$.

$\therefore$ per inch $\left(\frac{6,16,326}{53 \times 36}\right) = 324$ lengths.

Or 108 picks per inch in 3 fold yarn.

The expected tensile strength per inch width of the finished piece is calculated as follows :—

Warp-wise $12,598 \div 36 = 350$ threads are accommodated per inch.

The total denier of those threads$=350 \times 21 = 7,350$.

The total tensile strength at 3·4 grammes per denier $=7,350 \times 3{\cdot}4 = 24,990$ grammes.

Deduct 22% loss in the finished fabrics=5,497.

Tensile strength of the fabric warp-wise per inch$=19,493 \div 453 = 43$ lbs.

Weft-wise$=6,16,326 \div 50 \times 36 = 342$ threads are accommodated per inch.

Total denier of 342 threads=7,182.

Total strength at 3·4 grammes per denier=24,418 grammes.

Deduct 22% loss=5,371 grammes.

Tensile strength per inch 1,9047 grammes=42 lbs.

If the warp is prepared for, say six pieces, its length should be $6 \times 53 + 3$ yds. (remnant to be left on the loom) i.e. 321 yds. and 38 lbs. raw silk have to be secured for weaving the six pieces. The warp and weft threads in 3-fold condition can be used without being twisted into organzine and tram. If twisted a small allowance has to be made for take up. The usual pratice is to give a small twist to the weft threads. For details books on silk-weaving should be consulted.

Points to note :—

(1) Indispensability of tests in the Conditioning House of raw silk to be used in the production of standardised goods.

(2) Thickness (*mome-zuke*), weight and tensile strength of the fabric have been determined by the results of tests of the raw silk for average denier, boil-off loss and tensile strength.

(3) The quality of the texture of the fabric will be determined by the tests for evenness and freedom from impurities that is cleanness and neatness defects.

(4) The manufacturer has to determine, order and select what denier and quality of raw silk he proposes to use. The construction of the fabric can be varied as desired with different deniers, boil-off loss and tensile strength.

2. *Warping or laying out the warp* :—The yarn is wound on bobbins or reeds from which the required number of ends are drawn out and spread and the operation is carried out in various methods.

(a) The simplest method is to stick in the ground posts in a row to the length of the warp either straight out or in a rectangle and to spread two threads from end to end, one on each side of the posts and crossing them at the posts to secure leases.

(b) An improvement is to carry a number of bobbins or reeds in a frame and lay out many ends at a time.

(c) A further improvement is to have a fixed creel of bobbins from which the ends are drawn and laid out on a series of pegs on a wall.

(d) A still further improvement is a drum-like structure with protruding pegs revolving vertically on which the yarns from the creel of bobbins are wound spirally.

(e) Warping frames are also in use after the model of the warping mills with horizontal drums on which the warp threads are wound spirally in sections.

3. *Sizing* :—In the case of threads such as spun silk, degummed silk etc. a size has to put on the warp before beaming. Raw silk when used as warp does not need sizing.

4. *Beaming the warp* :—The warp threads are spread out to the width of the weft and wound on the beam with leases so that the threads may open out without entanglement.

5. *Looming* (*drafting and denting and setting*) :—The ends are put through the eyes of the healds and the dents of the reed, set in the loom and attached to the take-up beam. The hand-loom weavers prepare healds with string with hand for every new warp.

Weaving can be done after the warp is set in the loom. The weft yarn is wound on reeds for use in the hand shuttles on the ordinary spinning wheel (*charkha*). For use in shuttles for power-looms the thread is wound on pirns on pirn-winding machine.

F. ***Frauds in weaving.***

In the case of cheap cloths woven with raw silk frauds are frequently practised either by using a reed with closer dents at the edges and by putting in more picks at the ends of the piece. It is usually the margins and ends which are examined by the buyer and these fraudulent practices present a more compact texture at the margins and ends. Such practices are, however, never resorted to in the case of better class fabrics, such as *sarees*, *dhoties*, *thans*, etc.

G. ***False weighting of fabrics.***

In western countries silk fabrics are frequently weighted with tin salts which make the stuff feel thick and rustling and add a metallic lustre to it but at the expense of durability. In Japan tin-loading is as a rule prohibited by law and is practised with permission only in particular cases when the stuff so treated has to be marked as tin-finish.

In India false weighting is practised only in the case of inferior fabrics such as *korahs* which are marketed without degumming and washing and the loading is done with starch and sugar which are dissolved in water and this water used to wet the warp and weft yarns as weaving proceeds. Another form of weighting is adding thick coarse cotton strings in the weft at the commencement of weaving. These are practices which have crept into dealings between *mahajans* who issue raw silk by weight and take woven pieces by the same weight.

H. ***Finishing.***

The fabric after being removed from the loom requires to be finished for the market. Finishing may consist in the case of ordinary fabrics of :—

(a) being folded, ironed and wrapped in paper;

(b) being examined and dressed for the removal of loose ends, knots, dirty spots and calendered between hot rollers or pressed between smooth, thick card-board sheets or rolled on round wooden rollers tightly and in fully stretched condition and then folded and packed in card-board boxes ;

(c) being degummed, bleached or dyed and then calendered, folded and packed.

Class I.—Fabrics ordinarily woven are usually exported in undegummed condition and do not require any special finishing beyond being folded up and wrapped in a paper.

The fabrics woven for use in the canopy of parachutes and in which the weft threads may or may not be twisted into tram are required to be examined for defects, degummed, calendered, and rolled on a roller in a stretched condition.

Class II.—Fabrics are usually degummed and sometimes bleached especially when woven with yellow raw silk and then ironed, folded and wrapped in paper.

In Kashmir the weaving factories practise the following methods in the case of *sarees* etc. woven with twisted raw silk.

Degummed by being boiled for about one to two hours in a bath prepared with equal parts of soap, soda and *saji* and washed thoroughly in water. Then bleached by being dipped in potassium permanganate solution and washed and then dipped in hydrosulphide solution (1 lb. for 200 yards) for about 15 minutes and washed.

Then hammered by being placed in a folded condition on a round block of wood half buried in the ground and beaten with a thick heavy wooden club.

Then ironed, folded and packed in paper.

Another method followed is to degum and wash as above.

Spread out on grass outside to dry.

Bleach with hydrosulphide.

Spread on grass and water with a rose can for 2 or 3 days, hammer, iron.

Class III.—Fabric woven with degummed silk is usually folded up and sometimes ironed and marketed without washing of the size and starch used in weaving. For costly *sarees* with gold and silk laces used for designs care is taken to make use of clean degummed yarn. In Benares such fabrics are passed and lace work pressed between two revolving rollers. Plain fabrics having no lace work are sometimes washed with soap, hammered, ironed and then folded and packed.

I. *Details of some indigenous practices.*

These practices for weaving special fabrics, *sarees* etc. have been developed empirically through experience without scientific calculations necessary for standardised goods.

Class I fabrics.–At *Baswa*, Bengal:—For printed *sarees* with blouse pieces $6\frac{1}{2}$ yds. $\times$ 45″ each, warp for 11 pieces is prepared at a time with $2\frac{1}{2}$ lbs. *tana* silk and $4\frac{13}{16}$ lbs. *bharna* silk used in the weft, that is 11 oz. raw silk per piece when double threads are used per end or 8 oz. per piece when single threads are used per end. The operations are :—

(1) Winding or re-reeling the warp.

(2) Preparing bobbins or reeds for warping.

(3) Laying out warp.

(4) Spreading out and arranging the warp (*tabandi*) and filling rods for maintaining the leases and winding the warp on the beam.

(5) Knitting out healds.

(6) Fitting the ends into reeds.

(7) Setting in the looms.

(8) Winding the weft yarn.

(9) Pirn winding for shuttle.

(10) Weaving.

The pieces are cut out, folded and marketed. Degumming, dyeing and printing are carried out by dyers and printers. Cheap gown pieces, handkerchiefs etc. are woven in this manner.

A very inferior class of fabrics, called *jores*, is woven and some of them dyed with fleeting vegetable dyes and used by the bride and bridegroom at the marriage ceremony of the poor labouring classes and peasants.

Class II fabrics.—The warp threads are doubled and twisted and the weft threads doubled or trebled and may be twisted or untwisted. Fabrics woven with twisted warps and wefts are better and more durable than when woven with untwisted yarn. *Sarees* are frequently woven in this manner with twisted raw i.e. undegummed yarn with coloured and dyed yarns in the borders. The fabrics are then degummed and finished.

Class III fabrics.—Some practices in Bengal :—At Shibganj, Bengal, for 16 *saree* warp 5 lbs. *tana* silk for warp and 6 lbs. *bharna* silk for weft are used or about 11 oz. per *saree*.

At Mirjapur for a 14 *dhoti* (each 5 yds.×45″) warp 4 lbs. *tana* silk is used in the warp and 6 lbs. *bharna* silk in the weft or about 11½ oz. raw silk per piece.

At Berhampore, Bengal for a warp for 11 *sarees* (each 5½ yds.×46″) 4 lbs. *tana* silk for body and 2½ lbs. similar silk for border are used and 5½ lbs. *bharna* silk for weft. This works out to about 17½ oz. per *saree*. This fabric is of a better quality.

The operations are :—

1. Winding or re-reeling the raw silk for warp (*firan*).
2. Doubling and twisting of the warp threads. The border threads of the *saree* are usually 3 fold and the ground threads 2 fold *pakwan*.
3. Laying out the warp (*punnihata*).
4. First spreading weft-wise of the warp, examining and arranging and tying leases (*tabandi*).
5. Degumming the warp (*khari*).
6. Dyeing of border threads.
7. Spreading out and examining degummed warp while wet (*khari tabandi*).
8. Sizing the warp, usually done with starch of *khai* (parched rice).
9. Examining and arranging sized warp (*manda tabandi*).
10. Fitting in rods in place of thread leases (*joa* or *jhap gantha*).
11. Fitting the ends into the dents of the reed (*sanagantha*).
12. Beaming or winding the warp on beam (*joran*).
13. Border warp fitted on separately.
14. Knitting the healds (*baw-tola*). The string used in preparing the healds usually lasts for four warps.
15. Winding the weft threads (*bharna firan*).
16. Doubling the weft yarn.
17. Degumming the weft yarn (*bharna khari*).
18. Rewinding the degummed weft yarn.
19. Pirn winding i.e. winding the weft yarn on reeds for use in the shuttle as weaving goes on.
20. Weaving.
21. Finishing—(see below).

At Sonamukhi the practices are varied by degumming the raw silk hanks first. For a length of 24 *saree* (5 yds.×45″ each) pieces 6 lbs. *tana* silk for warp and 14 lbs. *bharna* silk for weft are used, or about 13½ oz. raw silk per piece. The warp prepared is 3 yds. extra in length and 2 inches extra in width than desired in the finished pieces. The operations for both warp and weft threads are :—

1. Degumming the raw silk for warp ; for 6 lbs. raw silk 1½ lbs. soda and 3 cakes Sunlight soap are used.
2. Rewinding the degummed thread.
3. Doubling, trebling or quadrupling the degummed thread as desired.
4. Sizing the degummed thread with starch from parched rice (*khai*).
5. Rewinding after starching.
6. Twisting the doubled yarn. The twisted yarn is handed over to weavers who carry out the following operations.
7. Sizing.
8. Rewinding after sizing.

9. Sorting out in batches of 20 yarns on a swift (*norma-kara*).
10. Laying out the warp.
11. Examining, arranging and leasing the warp.
12. Fitting the warp into a wide meshed warping reed.
13. Sizing the warp which is spread out and held in a stretched condition and brushed, the warping reed being pushed from one end to the other.
14. Beaming the warp.

The subsequent operations are the same as in the methods described above. The preparatory operations take about a month and actual weaving of the 24 pieces if regularly done takes about two months.

119. Manufacturing processes followed for fabrics woven with other raw materials than raw silk.

Manufacturing processes of *tasar* and *muga* raw silks are referred to under their respective sections. Rayon is dealt with like raw or degummed silk. Processes for fabrics from spun silk and staple fibres which are machine products are similar to practices followed for cotton.

Hand-spun silk (*matka*), hand-spun tasar silk (*kete*) and hand-spun *eri* are also woven like cotton.

Matka threads, however, being made of undegummed silk fibres drawn out of cocoons and mixed with pulse meal have to be processed in a special manner and the practices are the following. The thread is purchased in the form of small-sized hanks called *pheti*.

1. The *phetis* are rewound into large hanks each weighing about eight ounces.

2. The hanks are soaked in cold water for a night.

3. The soaked hanks are degummed by being boiled with soda or soda and soap at the rate of two ounces for every lb. of thread.

4. Degummed and washed thread is rewound into hanks weighing about an ounce.

5. Sizing is then done with size prepared by boiling meal of sun-dried rice (*atap*) at the rate of about five ounces of meal for a lb. of thread.

6. Rewinding in wet size and dried.
7. Bobbins prepared for warping.
8. Warping.
9. Beaming.
10. Knitting healds.
11. Denting.
12. Setting in the loom.
13. Weaving.
14. Pirning degummed thread for shuttles.
15. Dyed threads are used in borders for *sarees* and *dhoties*.

For *thans* for suiting threads are doubled and twisted.

120. Production of standardised fabrics in India.

The kinds of cloth woven in India (sections 112-3) fall into two classes.

I. *Sarees*, *dhotis*, *chadars* and similar cloths woven according to requirements and demands in different parts of the country itself are special products which hardly suffer from competition from outside and which have been the stabilising factor of the silk weaving industry of the country. Spun silk, rayon and staple fibres have enabled introduction of

varieties and cheapness of those products to suit all purses and in that sense may be taken to have helped the silk weaving industry.

II. Piecegoods such as *korahs, thans*, etc., which have been replaced largely by foreign imports in the country itself and which have lost the foreign market they at one time enjoyed. The reasons for loss of markets are, first, want of standardisation and secondly want of organisation to get standardised goods produced and marketed in bulk and in time to meet demands. Japan took steps to bring about both standardisation and organisation successfully and succeeded in capturing the markets for such goods not only in India but to a more or less extent in all countries and against European competition.

The special products, especially *sarees*, bodice-pieces and similar articles of wear do not stand in need of standardisation beyond what is practised at present. They are dependent more on improvement of designs, colours, etc. They can be easily modified to some extent to be suited for use in other countries, for instance, as lady's *lungis* in *lungi*-wearing countries such as Burma. *Korahs, thans, daryai, gulbadan* and piecegoods of this nature require to be standardised on the lines followed in Japan (sections 115-117). This will enable such goods to find two outlets viz. one in the country and the second in outside markets.

In the country the shops catering for European style articles and also Indian style ones such as coats, *chogas, chapkans*, etc. make use of these goods which are now largely imported.

In order to be able to produce standardised goods the following conditions have to be fulfilled.

I. The filatures must improve their processes so as to be able to produce standard grades of raw silk in deniers required for production of fabrics of different *momme-zuke* (section 116). The following specific cases will clarify the matter.

Fabrics for parachute canopies have lately been produced in the country with silk of different deniers 13/15, 20/22, 24/28, 28/32, 40/45. The necessity is raw silk of the same uniform denier. Construction and processing have of course to be changed according to the denier of the raw silk used in order to get the texture, MM, breaking strength and air porosity. The *thans* for parachute canopies are being manufactured in sizes 40 yds.× 36″. It was possible to manufacture this fabric on hand-looms, but in order to ensure uniformity in picks i.e. texture they have so far been woven on power-looms but can be done on hand-looms. The weight per sq. yard of these fabrics has been specified as 1·6 oz., that is the MM is 12 and all fabrics have been woven in one uniform MM.

In 1939 an enquiry was received by the writer from the Oiled Silk Industries Ltd., Letchworth, Hertfordshire, England for standardised *thans* 50 yds.×36″ in 4 MM and 6 MM qualities and the demand was stated to be 10,000 to 20,000 sq. yards per week from this firm alone. The demand could not be met for want of facilities and organisation for producing standardised pieces of this nature.

II. The manufacturers in India, both hand-loom and power-loom, require to be helped in the production of MM goods. This should be the function of the institutions like the Bengal Silk Technological Institute, Mysore Government Silk Weaving Factory, Kashmir Silk Weaving Factory. These institutions must first of all determine the demand of the kind of goods, work out manufacturing processes of goods in different MM and give the exact construction to weaving establishments and also indicate the process of finishing.

III. There must be an organisation :—

(a) to get standard goods produced by weaving establishments under the guidance of the institutions mentioned above ;

(b) to collect the goods ;

(c) to see that the goods produced are of the standard specifications, pieces not satisfying the specifications being kept back from outside markets ;

(d) to get all pieces finished in the same uniform process ;

(e) to market the pieces in bulk with certificate of the test of each individual piece i.e. conditioning and indicated by stamps on the pieces themselves as done in Japan (section 117), this conditioning being best done by a Government agency;

(f) to advertise and carry out propaganda; and

(g) to set up supplying agencies in different markets.

IV. An agency specifically to study the demand in different places and countries must be set up and is best attached to the institutions but it must also work in collaboration with the organisation for production and supply.

If these conditions can be brought about there is no dearth of markets and there is no limit to the expansion of the silk weaving industry. There must be constant efforts at cheapening the cost of production in all stages of the industry from cocoon upwards so as to be able to compete with Jápan and China.

V. *Dyeing*:—Dyeing is an important matter in silk weaving as the best and costly fabrics are produced with coloured threads or whole pieces are dyed.

Formerly dyeing of silk used to be done with indigenous plant dyes from indigo, madder, *kusum*, sapan wood, jak wood, turmeric, *kamala* with lac dye and introduced cochineal for red colours and myrabolans and catechu with iron for black. Several centres were famous for dyeing such as Amritsar, Benares, Belgaum, Nagpur and each province boasted of one or more centres less famous. In addition many weavers carried out their own dyeing. Indigenous dyes and dyeing practices were abandoned with the introduction of aniline and alizarine dyes from Germany and in order to push sale of their dye-stuffs German firms set up laboratories in India and organization to give advice free to the weavers at their houses. Indigenous dyes attract attention only when German supplies are stopped as happened during the last world war and also in the present one. Unfortunately expert practices developed empirically have mostly died out. This is a matter for proper scientific investigation.

APPENDIX I.

HOW JAPAN DEVELOPED HER SILK INDUSTRY.

The entire industry in all its stages is under the care of the Government. The details will be found in *Silk Industry of Japan* by the writer (1933) and more recent developments in the report of the Indian Trade Commissioner in Japan written for the Tariff Board in 1938 and published in the Written Evidence, Vol. I, 1940, pp. 1104-70. A brief summary of the measures adopted is given below :—

I. *Elaborate administrative organisation* as follows with ample budgets.

A. *Central Government.*

1. *Ministry of Forestry and Agriculture.*

(a) Bureau of Sericulture—in-charge of the whole raw silk industry.

(1) Section 1 (*Sangyoka*) has the charge of sericulture proper (1st stage of the industry) i.e. mulberry cultivation, egg production and supply, worms, rearing of worms, prevention of diseases, sericultural training, etc.

(2) Section II (*Kenshika*) has charge of the reeling industry (2nd stage of the industry) i.e. cocoons, reeling, raw silk, Conditioning Houses, export trade of raw silk, etc.

The Bureau has the following directly under it.

(1) The Imperial Japanese Sericultural Experiment Station at Nakano, Tokyo, which in 1929 had a staff of 23 experts, 20 assistant experts and 60 assistants and six branch stations in the prefectures with a staff of three experts, 14 assistant experts and 29 assistants. The total technical staff was therefore 149 who were engaged in the problems concerning the Raw Silk Industry i.e. mulberry, worms, cocoons and reeling and were responsible for improving the industry to its present state.

(2) The Imperial Institute of Silk Industry dealing with problems on raw silk and its properties in relation to weaving including boiling-off, dyeing and finishing of fabrics.

(3) The two Raw Silk Conditioning Houses at Yokohama and Kobe.

(4) Two Registration Offices for "Raw Silk for Export" at the same places as above.

(5) Foreign raw silk markets investigation office at New York, U.S.A.

(6) All measures for the welfare and prosperity of the Raw Silk Industry, including enforcement of laws, giving of loans, subsidies, bounties and bonuses, initiating and carrying out special investigations and all work on similar lines.

2. *Ministry of Commerce and Industry* has charge of the third stage of the industry i.e. weaving of fabrics and other manufactures, examination of export goods, trade in such goods, etc.

It has charge of :—

(1) The Tokyo Textile Engineering University, which carries out research and experiments in all phases of fabric manufacturing industry and teaching.

(2) Laws and regulations for fabric manufacture and export trade in manufactured goods.

3. *Ministry of Education* has charge of sericultural education i.e. all schools (16 sericultural and 225 agricultural in 1929) and the three sericultural colleges and a college class teaching sericulture.

B. *Prefectural organisation for the raw silk industry* :—Prefectural Governments i.e. district administrations, the districts being known as provinces or prefectures with the designation of the head as Governor.

Forty-five out of forty-seven prefectures in Japan have each a separate Sericultural Department.

An Assistant Governor (one out of three Assistant Governors in each district) is in charge of the sericultural department with (a) secretary (*Sanshika*) and (b) sericultural adviser and director of all sericultural organisations in the prefecture.

The prefectural organisations are: (1) Controlling Stations (*Torishimari Jo*). In the whole of Japan in 1928 there were 206 main and 137 branch stations with 66 experts and 767 assistant experts and 234 clerks and employing 69,559 temporary hands mostly microscopists for seed examination. Their principal functions are to supervise and organise disease-free seed production and supply, expansion and improvement of mulberry and supervision of guilds, etc.

(2) Experiment Stations (*Sangyo shikenjo*)—The 45 silk-producing prefectures had 48 main and 21 branch stations with 99 experts, 256 assistant experts and 72 clerks. Their functions are research work, experiments for improvement of mulberry, worms and reeling, production, maintenance and supply of parent stock of worms and their supply for seed production for general rearers, training and distribution of mulberry, etc.

(3) Sericultural Committees composed of both officials and non-officials. Their functions are directed specially towards mulberry and its improvement and maintenance and expansion.

C. *Prefectural organisation for the weaving industry:*—The prefectural governments of silk weaving districts maintain :—

(1) Raw Silk Conditioning Houses in silk weaving districts using large quantities of raw silk.

(2) Industrial textile experiment stations for research and experiments in processing, weaving, dyeing, printing and finishing and machinery.

(3) Technical institutions for teaching silk weaving.

(4) Cloth Conditioning Houses for export goods.

D. *Budgets* :—The Central and Prefectural Governments have separate budget provisions.

The budget of the Bureau was 2,255,938 Yen in 1927 and 13,538,657 Yen in 1936.

The prefectural budgets for raw silk industry were 8,709,376 Yen in 1928.

The educational budget only for three sericultural colleges and a class (besides these there were 241 sericultural, agricultural and other middle schools teaching sericulture) was 512,000 Yen in 1928.

The budget of the Commerce and Industry Department for silk industry is separate.

An idea of the work carried out by the Bureau of Sericulture will be obtained on reference to Tariff Board's Written Evidence, Vol. I, 1940, pp. 1150-1155 and *Silk Industry of Japan*, pp. 65-68 and that of the work of the Prefectural Governments to pp. 69-73 of the latter publication.

The measures may be classified under the following heads :—

II. *Measures for the Raw Silk Industry* (i.e. the first two stages of the industry).

(1) Research and experiments for improvement of mulberry, worms, cocoons and raw silk.

(2) Practical training of staff, students and workers.

(3) Organisation of production and supply of disease-free seed (eggs) of the best races of worms.

(4) Organisation and help for cultivation of good mulberry and its maintenance.

(5) Control of diseases of worms and mulberry.

(6) Improvements of reeling machinery and methods.

(7) Control and expansion of production and trade of raw silk to maintain standard and reputation of the commodity.

(8) Sericultural education.

(9) Subsidies and bounties liberally given.

(10) Associations, guilds and societies.

(11) Laws and regulations for co-ordination and control.

(12) Special investigation whenever considered necessary for every stage and phase of the industry.

(13) Special committees set up whenever considered necessary for carrying out the work necessary.

III. *Measures for the weaving industry.*

1. Research and experiments in the Central Technical Institute now called the Tokyo Textile Engineering University and Industrial Experiment Stations started in the silk weaving districts for improving and standardising processes such as, throwing, dyeing, boiling-off, weaving processes, finishing, embroidery, etc.

2. Facilities in the Textile Engineering University and Technical Institutes started in silk weaving districts for training in processing and weaving of silk and operating improved machinery and looms. These institutes helped in the introduction of power-looms.

3. Introduction of power-looms in place of hand-looms. Cheap power-looms were made as far as possible with wooden parts so that with cheap electricity available in the villages they could be adopted in place of hand-looms and worked in houses in the same way as the old hand-looms.

4. Establishment of weavers' guilds which survey demands, instruct the members as to the goods to be produced, collect the goods, examine them, get them finished and market them in bulk. The guilds also arrange for exhibition and propaganda.

5. Survey of the goods in demand in different markets in different countries and making this information available to weavers' guilds. The Department of Commerce and Industry sends out both businessmen and textile experts to all countries. The Fukui Prefecture Textile Guild sent out such investigators to all countries. It is one of the functions of the Japanese Consuls wherever posted.

6. Amalgamation of concerns in the same line of work viz. inspection of raw silk used, throwing, dyeing, boiling-off and finishing, in order to ensure uniformity of products. Use of thrown i.e. prepared warp and weft yarns (organzine and tram) and ready-dyed yarns and centralised boiling-off and finishing help to cheapen cost of production.

7. Fixation of specifications for different standards of export goods.

8. Compulsory examination of all manufactured goods for export in Government Cloth Conditioning Houses which are to pass only those goods for export which come up to the standard specifications and reject others which can only be used in the country. Cloth Conditioning Houses were operating in twelve centres in 1929.

9. Laws and regulations to control and guide every branch of the industry.

10. Close co-operation of the Government with the manufacturers and help in the form of subsidies and banking facilities.

IV. *Laws and regulations—Associations, etc. formed under them.*

Only a general idea of the scope of the laws is given here. A long list of them will be found in the Tariff Board's Written Evidence, 1940 p. 1137.

A. *For the Raw Silk Industry.*

Sericultural Law :—The Sericultural Law passed in 1911 and amended in 1917 provides for: (1) control of diseases, viz., flacherie (*Nan-ka-byo*), muscardine (*Ko-ka-byo*), pebrine (*Biryu-shi-byo*), grasserie (*No-byo*) and the fly pest (*Go-so-byo*) by all sericulturists, the term sericulturist including rearers of silk worms, raisers of seed (eggs), manufacturers of silk threads and floss silk and brokers and keepers of dry cocoons, silk waste and dead moths,

(2) regulation of production and importation of seed (eggs), (3) regulation of sale of eggs, cocoons, and mulberry seedlings and grafts, (4) regulation of examination of silk, (5) formation of Central Raw Silk Guild and (6) granting of subsidies.

Regulations under the Sericultural Law:—In order to give effect to the provisions of the above law elaborate Regulations have been formed and are in force, the main purports of which are given below under different headings. Violators of the prohibitive clauses of the Law and Regulations may be fined up to Yen 500. The Regulations specify the formation and methods of work of the following :—

(1) The Imperial Sericultural Experimental Station, Nakano and its six branches.

(2) Controlling Stations (*Sangyo Torishimari Jo*) by prefectures.

(3) Prefectural Experimental Stations and their branches.

(4) Prefectural Conditioning Houses and their branches.

(5) Varieties of worms to be reared.

(6) Control of the parasitic fly and diseases generally.

(7) Control of pebrine disease.

(8) Control of production and sale of mulberry seedlings and grafts.

(9) Sale of cocoons.

(10) Signboards and hawking.

(11) Supervision of dealers in seed and cocoons.

(12) Formation of Leagues of Sericultural Guilds and of a Central League.

(13) Subsidies.

The world-wide economic depression which set in about 1929 necessitated collective control of the various complicated phases of the industry and the Raw Silk Industry Association Law was passed in 1931 which divided the entire industry into six separate branches, grouped the associations in the prefectures under these branches and organised the cognate associations into central federation as follows :—

(1) The National Federation of Silkworm-egg-card Producers' Associations (*Zenkoku Sanshugyo Kumiai Rengokai*).

(2) The National Federation of Cocoon Producers' Associations (*Zenkoku Yosangyo Kumiai Rengokai*).

(3) The National Federation of Filatures' Associations (*Zenkoku Seishi Kumiai Rengokai*).

(4) The National Federation of Co-operative Raw Silk Manufacturers' Associations (*Zenkoku Sangyo Kumiai Seishi Kumiai Rengokai*).

(5) The Raw Silk Traders' Guild (*Kiito Tonyagyo Kumiai*).

(6) The Raw Silk Exporters' Association (*Kiito Yushutsugyo Kumiai*).

These six federations operate, in co-operation with Government institutions, under a supreme controlling body organised by them, known as the Central Raw Silk Association of Japan (*Nippon Chuo Sanshi Kwai*) which, as laid down in article 69 of the Raw Silk Industry Association Law of 1931, is a legally constituted body set up to " facilitate better connection between the federations and local associations, to promote the development of, and exercise the control over the silk industry ". The Committee of the Central Raw Silk Association which is the voting machinery of the organisation, consists of 30 representatives selected by the affiliated federations (each member federation is allowed to select five representatives) and special representatives appointed by the Government (whose number is limited to under one-fifth of the total number of the representatives). The Central Raw Silk Association is not only responsible for enforcement of the various control measures over all lines of the Raw Silk Industry, but also to act as a channel through which the raw silk interests approach the Government for the materialisation of their schemes. Moreover, the Association conducts various studies and investigations for the promotion of the industry and undertakes publicity work, etc., in this connection.

For details about them Tariff Board's Written Evidence 1940, pp. 1131-1142 may be referred to.

An idea of the Associations, Guilds and Societies formed and working in the prefectures, counties and villages will be obtained from the following :—

Prefecture.		County.	Village.
1. Federation (*Rengokyo Kai*)	A. Mulberry nursery men's guild (*Sobyo* or *Kwanai Dogyo Kumiai*)	A. Branch	
	B. Egg Producers' Guild (*Sanshu Dogyo Kumiai*).	B. Branch.	
	C. Seed Traders' Guild (*Sanshu Hanbai Dogyo Kumiai*).	C. Branch.	
	D. League of Unions of Rearers' Associations in the Prefecture.	D. Union of Rearers' Associations in the county.	D. Rearers' Associations or Union of such associations when more than one in a village.
	E. Cocoon and Raw Silk Traders' Guild (*Kenshi Dogyo Kumiai*).	E. Branch	
	F. Sericultural Teachers' Associations (*Yeosan Gijitsu Kayokai*).	F. Branch.	
2. Filatures Guild (*Seishi Dogyo Kumiai*).			
3. Prefectural Union of Co-operative Silk Sale Societies (*Saitama sha*).			
4. Branch of the Silk Associations of Japan (*Dai Nihon San-shi Kai*).			
5. An Association or rather a periodical meeting to discuss sericultural matters (*San Ken kyo Kai*). (This is recently formed).		G. Co-operative cocoon drying, storing and sale society.	

The details about them will be found at pp. 98-109, *Silk Industry of Japan.*

B. *For the weaving industry.*

The two principal laws for improving quality and maintaining the reputation for the uniformity and quality are :—

(1) The Law of Staple Products Guilds and (2) Law for control of silk manufactures for export.

(1) *Law of Staple Products Guilds* (*Juyo Bussan Dogyo Kumiai Ho*). (Law No. 15 of 5th year of Taisho, 1916).

Those who are engaged in producing or manufacturing important staple products (*Juyo-Bussan*) or are engaged in the trade of these products can organise a (*Dogyo Kumiai*) guild among themselves or with those who are engaged in business which have a special close connection with these products. Staple products and things allied to them are declared as such by the Minister of Forestry and Agriculture.

The objects of the guilds are removal of defects and promotion of profits of those engaged in the profession co-operatively.

Organisation of a (*Dogyo Kumiai*) *guild* :—A guild is organised when two-thirds of the people engaged in the business agree. When a guild embracing two or more different professions is to be organised the consent of two-thirds of the members of each profession is necessary. Similarly dissolution also requires the consent of two-thirds of the members.

Those who are engaged in the same profession must join the guild. The Minister can grant an exception if he deems it necessary.

To promote mutual benefit and to attain their aims guilds can form themselves into a league (*Dogyo Kumiai Rengokai*). They should have the following office bearers, viz., President one, Vice-President several and several committee members. Besides, they may have other officers according to regulations. They can make provisions in their statutes for examination or inspection of the products of the members and against violation of the regulations and can levy compensation for losses owing to such violation or confiscate the things which cause violation. They must have examiners for carrying out this inspection.

The Minister of Agriculture and Forestry has complete control over the guilds. He specifies what is to be considered as staple export product, sanctions formation as well as dissolution of a guild or league of guilds, can cause a guild or league of guilds to be organised, can alter their jurisdiction, method of work, decision, budget, method of collecting funds and statutes, can order a guild to join a league, approves of the appointment and dismissal of examiners as well as office-bearers, can punish office-bearers and examiners for any action against the law or against the interests of the guild or league of guilds and can demand reports and investigate the affairs of a guild or league of guilds.

Provision is made for punishment with fine upto Yen 500 of those who do not join a guild when formed, of office-bearers and examiners if they refuse to work or hinder work, of a guild for not joining a league, of those who counterfeit trade marks and certificates and of those who receive or offer bribes.

Regulations under the law of staple products guild require that only a *Dogyo Kumiai* can use this word in its name and that the jurisdiction of a guild except in special cases cannot be larger than a prefecture but must be larger than a city or county. Detailed instructions are given as to how a guild or league of guilds is to be initiated and formed as well as how it is to be dissolved, how office-bearers are to be elected, how voting is to be done (votes are equal in all cases), how meetings are to be conducted and records kept and how arbitration, if decided upon, is to be carried out. Alteration of any rule requires the consent of two-thirds of members in the case of a guild and of two-thirds of representatives in the case of a league. The supervisory powers of the Minister are delegated to the Governor of the Prefecture.

(2) *The law of the control for export silk fabrics.*

1. No export silk is allowed to be exported for business purposes unless it has passed the inspection made by the Imperial Japanese Government Silk Inspection Office in accordance with the provisions of the ordinances. This does not apply, however, to a fabric for which permission has previously been given by the Minister of Commerce and Industry under special circumstances.

2. In order to maintain or raise the reputation of export silk fabrics, the Minister may issue ordinances for restriction or prohibition of weighting of export silk fabrics and for indications by which the quality and kind of weighting are to be distinguished or other matters.

3. No refining business of export silk fabrics is allowed to be carried on without obtaining the permission of the Minister in accordance with the provisions of ordinances.

4. In order to maintain or raise the reputation of export silk fabrics, the Minister may issue necessary ordinances regarding factory arrangements for refining or dyeing of export silk fabrics, the mode of operation, the materials to be used or other matters, or may stop work altogether.

5. When a refiner of export silk fabrics has violated, in carrying out his work, the provisions of this law or ordinances issued in conformity with this law, or the measures taken in conformity with this law or has acted against public interest, the Minister may cancel the permission already given in accordance with article 3.

6. Competent officials may, if necessary, visit factories, shops, warehouses, or other places, and inspect the goods, books, or other articles, under a certificate of authority.

7. Any stamp or mark impressed by the Imperial Japanese Government Silk Inspection Office on export silk fabrics shall not be defaced, removed or cancelled without a proper reason.

No export silk fabric, on which the stamp or mark is impressed in accordance with the provisions of the preceding paragraph, is allowed to be exported if the stamp or mark is defaced, removed or cancelled.

8. Persons coming under the purview of any one of the following shall be punished with a fine not exceeding 1,000 Yen.

(1) One who has exported or is going to export silk fabrics, in violation of the provisions of article 1, or of paragraph 2 of the preceding article.

(2) One who has violated the provisions of article 3 or of paragraph I of the preceding article.

(3) One who has violated the provisions of ordinances issued in conformity with article 2 and article 4, or measures taken in accordance with them.

9. One who refuses, hinders or evades the visit or inspection of competent officials without proper reason, or does not give answers to inquiries or makes false statements, shall be punished with fine not exceeding 500 Yen.

10. No person, who deals with export silk fabrics, may be exempted from punishment for violation or infringement of any provisions of the present law or ordinances issued in conformity with it or measures taken in accordance with it, by his representatives, house master, family inmates, employees or trade assistants despite the fact that such violation or infringement was not committed by his direction.

11. The penal clauses to be applied to a dealer of export silk fabrics when he has violated the provisions of the present law or the ordinances issued in conformity with it or measures taken in accordance with it, shall be applied to a juridical body, to the director or official who carries on the business for the juridical body and in case of a minor, or a person adjudicated to be incompetent to manage or control his own business or property, to the legal guardian or representative. A minor in possession of the capacity to carry on business will himself be liable.

APPENDIX II.

LINES OF RESEARCH IN SERICULTURE.

SERICULTURE is specially recommended as one of the main subjects for research under Animal Husbandry by the Animal Breeding Committee of the Advisory Board of the Imperial Council of Agricultural Research. It is a highly technical special science and its problems are quite distinct from those of general agriculture. As its complexities are not generally understood it seems necessary to explain them briefly so that the nature, necessity and scope of research may be evident.

Sericulture is production of silk cocoons by rearing silkworms fed with mulberry leaf which is their only food.

Mulberry, a fruit tree, has to be grown in a manner so that not fruits but abundant leaves may be available to feed millions of worms kept indoors at one place. There are many varieties of mulberry and many races of worms with different habits. Different varieties of mulberry and different races of worms are found to exist in different countries adapted to their climatic conditions and sericulture is carried on with them. Some races of worms generally existing in cold climates are univoltine (one brooded) and produce cocoons only once in the year. The worms existing in warm climates are multivoltine (many brooded) and produce cocoons several times in the year. Generally speaking the former produce better cocoons with larger silk content than the latter. The aim is to have more silk content in the cocoon and more raw silk from it. The problem could be easily solved if the higher yielding races of worms could be adopted and reared everywhere. This is not possible as all worms do not thrive in all climates. But through hybridisation and selection better yielding races of worms are possible to be evolved suited to warm climates. In fact all worms in all countries are possible to be and have been improved. In the same way there are different varieties of mulberry and different methods are followed in growing mulberry which show difference in food value for the worm. Better mulberry enables better races of worms to be reared and mulberry accounts for about two-thirds of the expense of cocoon production. Both mulberry and worms are subjects of research.

Sericulture as an industry is successful only when carried out as a subsidiary occupation by the rural agricultural population. They grow mulberry, procure silkworm eggs, rear the worms mainly with their family labour and sell off the cocoons. Provided mulberry leaves are available rearing takes only about a month. No agricultural crop brings in cash to the family so quickly and so many times in the year, as in the plains of India cocoons can be and are raised about four to six times in the year according to season and availability of leaves. Mulberry can be grown in various ways, as bush like field crops, as medium trees and trees on high lands. Once established mulberry lasts for many years, only requiring cultivation, manuring and pruning in season.

Research will pay in sericulture which being the concern of poor peasants cannot flourish without State help and organisation. Its development everywhere has been proportionate to the State help it receives.

There has been hardly any or rather no research on sericulture in India though its necessity had been felt and stray attempts made. Thus foreign mulberry varieties had been imported which, however, could not be worked into the indigenous system of cultivation. Attempts only spasmodic were made to improve the poor cocoons of Bengal by appointment of French experts. Kashmir imports univoltine French eggs and rears them and finds, now that the supply has been interfered with by war, eggs at present produced locally do not do well. That research pays will be evident from the fact that Mysore at present gets much better cocoons from first-cross eggs from indigenous mother moth mated with a foreign male. But stoppage of supply of foreign moths has presented a serious problem. Fixed hybrid races evolved only recently in Burma by the writer after crossing multivoltine moths with univoltine father and introduced in Bengal are giving much better results and have practically replaced one of the two indigenous races.

It should be pointed out here that Kashmir, Jammu and the Punjab rear univoltine races of worms producing cocoons only in spring and remaining as eggs for the rest of the year. Such worms are possible to be reared all along the foot hills of the Himalayas from the North-Western Frontier Provinces to Assam. Multivoltine races of worms yielding several crops of cocoons during the year are reared in all other areas. Problems of univoltine and multivoltine rearing areas are somewhat different. The univoltine rearing areas make use of tree mulberry and the multivoltine rearing areas of bush mulberry. Midway between tree and bush a system of dwarf trees, described as high bush (sections 33-38) has been developed suitable for several rearings in a year.

The lines on which research is necessary are indicated below. Some of the items form fit subjects for research in Universities and can be carried out with the co-operation of the Sericultural Departments while some are best done in sericultural research stations.

On mulberry.

1. *Selection of varieties* :—After a thorough study of about four hundred varieties about ten varieties have been selected as suitable for different areas in Japan. Mulberry is a wholly unworked problem in India. A systematic survey of varieties growing in forests and other areas all over India, their collection, cultivation, isolation and study of their behaviour are necessary. Foreign varieties also should be included in the study. A preliminary study indicates that although growing at the same place the leaves of different varieties differ in food value, growth and yield.

2. *Study of varieties* :—

The lines of study indicated are :—

(a) Chromosome numbers of varieties.

(b) Chemical composition of different varieties.

(c) Biochemistry, carbon assimilation, protein and carbo-hydrate metabolism, vitamin values, etc.

(d) Drought resistance as well as resistance to water logging of varieties which will include study of the root system. Mulberry is generally an unirrigated plant even when grown as a field crop.
Excessive rain causes deterioration of food value for worms.

(e) Genetics of mulberry with special reference to inheritance of characters especially in grafting which is followed as the best method of raising mulberry. In practice it is found that scions of some varieties do not do well on some stocks.

3. *Soils in relation to growth and health of mulberry.* This will include:—

(a) Study of optimum condition for mulberry growth, producing leaves with high nutritive value for silkworms.

(b) Effect of organic and inorganic manures on mulberry.

(c) Mineral requirements of mulberry.

(d) Preliminary studies by N. N. Roy have revealed some important relationships.

(1) *Tukra* disease causing crumpling of leaves and stuntedness of growth of mulberry has been found to be associated with phosphate deficiency in the soil under certain conditions.

(2) *Bishal pata* disease of mulberry leaf which proves poisonous to silkworms has been found to be associated with deficiency of potash.

(3) Unbalanced condition of mulberry leaf with low protein and high iron content has been found to be responsible for disease and death of worms.

(4) Presence or absence of minor elements, copper and manganese, has been observed to be associated with richness or otherwise in protein and carbohydrate contents of leaves.

(5) Acidity in the soil has been observed to be associated with root disease of mulberry.

4. *Physiology of mulberry plants* :—Mulberry is grown as

(a) low bush from cuttings and seeds,

(b) medium trees and trees from cuttings and seeds,

(c) medium trees and trees from grafts.

The food value of the three forms has been observed to differ, grafts being the best in this respect. But grafted trees have been observed in Bengal to fruit more heavily than others while bushes hardly fruit. Fruiting at the expense of leaf production is a disadvantage for the sericulturist. The stems of trees raised from the cuttings decay in the course of about ten to fifteen years.

5. *Biological assay of mulberry :—*

(a) Nutritive value and digestibility of mulberry grown in different manner.

General observation so far is that leaves from grafted trees are more nutritious and enable worms to resist diseases.

(b) In feeding young worms with tender leaves the topmost one and the leaf below it are suspected to be injurious.

The tender top shoot with the tender leaves on it are some times observed to be associated with grasserie disease in worms fed with them. N. N. Roy found traces of a highly poisonous substance in such shoots, in some cases this substance showing polyhedral crystals of the type found in the blood of worms suffering from grasserie but unfortunately died before he could pursue the investigation.

(c) Variations in carbo-hydrate, protein and fat contents in different varieties, in different stages of growth, during day and night, during storage, when chopped before supply to the worm and when harvested in different hours and with or without twigs and stalks. Similar problems with moisture.

(d) Correlation of nutrients in the leaf with development of silk gland and silk content in the cocoon. Similar work on longer feeding in the last stage of the worm.

6. Broad and large-leaved varieties of mulberry should be aimed at.

7. Economical method of growing mulberry so as to reduce cost of production. Can tree mulberry be grown in such a way that its cost can be recovered from intercrops ?

On silkworms.

1. Acclimatisation of suitable univoltine worms in India so that the univoltine rearing areas may be sure of seed supply in this country and univoltine worms required for F_1 cross or hybridisation experiments may be available.

2. Hybridisation so as to secure improved cocoons either from first crosses or from fixed hybrids.

Fixed hybrids have an advantage over F_1 crosses in that when once fixed they continue to behave as ordinary multivoltines while in the case of the latter the pure races have to be maintained and reared and crossing done for each rearing. Research directed towards production of improved fixed multivoltines is therefore very necessary in the interest of sericulture in the plains of India. Fixed hybrids seem to be capable of gradual improvement up to nearly the quality of their superior univoltine parents through infusion of fresh doses of univoltine blood into them.

3. Genetical study of the races of silkworms in all aspects.

4. Physiology of silkworms :—It is observed that with improvement in health and cocoons the proportion of males in the progeny of the multivoltine moth increases. There are evidences to indicate that this is also connected with mulberry grown on particular soils used as food for the worms. This is a great disadvantage as it is possible to get two females fertilised by one male, thus saving cocoons for reeling. More males means more waste of cocoons and less eggs. The Mysore Department has been doing some work on refrigeration of eggs and seed cocoons at Channapatna in order to retard hatching to suit weather conditions in rearing.

5. Relationship of the life of the worm with climate, especially heat, cold and moisture.

Univoltine eggs require to be subjected to intense cold, about 30° F, for a period of hibernation for proper hatching. Multivoltine eggs hatch under normal conditions. Incubation of hatching of eggs is a point on which research is necessary. Incubation commences in the case of univoltine eggs when they are taken out of hibernation and in the case of multivoltine eggs soon after oviposition. Temperature and humidity during incubation have a direct bearing on hatching and on the health of the worms later on. Research is necessary to elucidate many obscure points.

6. The aim will be to secure cocoons not only with high silk content but also with high reelability index (section 66,V) and with minimum boil-off loss (section 76).

7. Uniformity of cocoons reared in the whole rearing area is very necessary for facilities of reeling and production of uniform grades of raw silk. About 1913 there were about one thousand varieties of worms reared in the different parts of Japan with the result that cocoons collected by reeling concerns even from the same area consisted of several kinds. This was a serious drawback in organised reeling. The Imperial Japanese Sericultural Experiment Station brought about uniformity so that by 1926 about 72 per cent of the rearing was of the same uniform cocoons.

8. Analysis of silk fibre of different races of worms including that of silk glands.

9. Physical study of silk fibre.

The above two items will help production of ligature gut.

10. Economical method of rearing so as to reduce cost of production.

On diseases of silkworms.

I. The diseases from which silkworms suffer are several:—

(1) Pebrine due to the attack of an internal protozoal parasite is both hereditary and contagious. Pasteur's method of control by elimination of eggs of infected mother moths through microscopic examination of their body tissues in every generation is now a routine practice in sericulture, supplemented by precautions against contagion and use of disinfectants.

(2) Flacherie is like diarrhoea and cholera of human beings; several bacteria are found in association with it but their nature is not correctly understood. This disease however causes more loss in India at present than any of the other diseases.

(3) Grasserie is like jaundice of human beings. Several bacteria are found in affected worms and the presence of a virus suspected but the causative agent is unknown.

(4) Muscardine is due to the attack of a fungus and is controllable by the use of disinfectants.

(5) There are a few obscure diseases whose nature and cause are not understood.

Each of the diseases is a subject for research.

II. From the practical view point as regards control of the diseases three lines of work suggest themselves, viz.

(a) Evolution of resistant races of worms. The evidence of usefulness of this line is found in the recent experience in Bengal where two indigenous races of worms have been reared all along viz. Nistari which does well in hot weather and Chotopolu which does well in cold weather.

Chotopolu however is badly liable to suffer from pebrine which causes frequent crop failures. The new hybrid races, Nistid and Nismo, which do quite well in cold weather have proved to be much more resistant and have now replaced Chotopolu almost wholly within about three years.

(b) Improvement of the nutritive value of mulberry leaf has been observed to enable worms fed on such leaves to resist all diseases. At the onset of grasserie disease substitution of leaves of grafted trees for those of ordinary bush enables affected worms to overcome the disease.

(c) Thorough study of the diseases themselves are expected to suggest other lines of control.

For lines of research for *eri*, *muga* and *tasar* silks see the respective parts.

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SOLVENT EXTRACTION OF OILS

Applications.

In the processing of any oil material with a fairly high solids content, the greatest yield of oil is obtained only by extraction with solvents and a greater portion of various oilseeds and oil cakes met with in commerce can have almost all of their oil contents removed by this process. This constitutes one of the outstanding merits of the solvent system. When applied directly on the processing of oilseeds, this process is relatively more advantageous in cases where the oil content is low, as soya beans. It can, however, be applied with the same efficiency for seeds which are high in oil contents, by first reducing the oil portions by a preliminary expelling process in some form of low pressure expellers ; and the resultant cake can then be suitably treated in the extraction process.

The oil content to which oil cake can be reduced by mechanical expression is approximately the same for all oilseeds, i.e., about 6 to 9 %. Consequently the oil, unrecoverable by mechanical expression, in terms of percentages of total oil, increases progressively with the decrease of oil content of the seed. The following table shows a comparative yield of oil obtained by the two processes as applied on low medium and high oil content seeds and it will be observed that the application of solvent extraction process over the mechanical one increases the yield of oil in soya beans by 40 per cent whereas in the cases of cotton seeds and groundnuts the increase is only 18 and 7 per cents respectively.

In some cases the application of solvent extraction to certain oilseeds is limited by mechanical considerations. Best extraction is usually obtained in a continuous counter current system where the solvent and seeds contact each other while moving continuously in opposite directions. Most of these systems, however, lose their efficiency if the seed flakes lose their original forms, because if the latter disintegrate under the influence of the solvent, it becomes difficult to separate the fine particles from the miscella, besides impeding the uniform circulation of the solvent through the entire mass of the seed.

Some difficulty is also generally experienced in the extraction of cotton seeds owing to the peculiar action of the majority of the solvents on the colouring matter in the cotton seed.

Descriptions.	Soya beans	Cotton seeds (meats)	Groundnuts (Kernels)
Oil contents.	Low	Medium	High
Composition percentage			
Oil	18.5	30.0	50.0
Solids	70.0	63.0	45.0
Moisture	11.5	7.0	5.0
Yields by mechanical Expression Per 100 maunds.			
Oil ....Oil	12.4	25.0	46.4
Cake ..Oil	6.1	5.0	3.6
Solids	69.5	60.0	43.0
Moisture ..	8.0	6.0	5.0
Per cent oil in cakes..	7.5	7.0	6.8
Per cent total oil Recovered.............	66.5	82.8	92.8
Yields by Solvent Extraction			
Oil ....Oil	17.9	29.5	49.66
Cake ...Oil	0.6	0.5	0.34
Solids	69.5	60.0	42.8
Moisture.....	8.0	6.0	5.0
Per cent oil in cake.	0.8	0.8	0.7
Per cent total oil recovered.	96.7	98.4	99.32
Comparison of yields			
Yield by mech. expression, mds. oil 100 mds. seeds.	12.4	25.0	46.4
Yield by solvent extraction mds. oil/100 mds. seed.	17.9	29.5	49.66
Increase by solvent Extraction mds.	5.5	4.5	3.26
Increase by solvent extraction%	40.3	18.0	7.2

Table showing comparison of solvent extraction and mechanical expressi[on] processes as applied to seeds of various oil contents.

From the commercial point of view the full advantages of the process depend on various factors. If a choice is to be made between the pressing and the solvent methods, it depends mostly on the nature of the seed and whether the cake obtained from them is usable as cattle feed or not. Thus in the case of castor or mahùa seeds, even when treated by the pressing methods their cake so obtained is not at all valued for cattle feeding. In such cases the yield of oil is the only primary consideration which points to the adoption of this method for such seeds. When the cake is unsuitable as a cattle feed, the only other important outlet lies in its use as a manure or fertiliser ; and it is an established fact that the presence of an oil or fat in a fertiliser prevents the latter from being attacked by those organisms which convert the constituents of the fertiliser into immediate soil food and they are thus prevented from being absorbed by the soil. The solvent extraction process, therefore, has a very great advantage of producing oil freed cakes which have excellent fertilising properties. Besides this, the expeller and the hydraulic press cakes require disintegration before use as a manure whereas the extracted cake is in the form of a powder and can be used directly thus saving the breaking charges and at the same time remaining as much better fertilisers.

Oil cakes constitute by far the largest by-product of the oil crushing industry and as such are used both as cattle feed and as fertiliser. There are certain oil cakes like Rape, linseed, groundnuts etc., which are used for both the purposes and the solvent extraction method can surely be used to recover 8 to 9 per cent of the oil from that proportion of the cake which is used as a manure, as the oil contained by them is otherwise virtually lost. It will have been seen that the unexpressed oil in the cake of the pressing method does no good to the soil or to animal and crores of rupees are thus lost in this form. With the adoption of the solvent method great industrial wealth can, therefore, be saved.

Oil cake, when its last traces of oil are removed, can easily form the most important ingredient of the moulding powder for the plastic industry.

For the oil refining and increased production of vegetable ghee, it will be appreciated that vegetable oils obtained from suitably operated extraction plants will prove to be easier and cheaper in fining and the high yield of oil from the seeds will enormously help in lowering the cost of the final products.

Commercial Aspect Of The Process.

We thus see that the solvent extraction process has distinct advantages over the pressing method particularly when (1) the cake is not used as a cattle feed by reason of the nature of the seed as in the case of castor and mahua seeds, and when (2) the cake, although suitable as cattle feed is not wholly used for that purpose but most of it goes for manure as in the case of mustard, groundnut and linseed cakes and thirdly when (3) the cake is unusable as a cattle feed, even with low oil content, sufficient to allow the necessary fatty matter to the cattle.

Which method is best to adopt under these circumstances is a matter of close study but it can be said that the solvent extraction process is the only known method to successfully recover most of the oil now virtually lost by as much as about 98 per cent of the quantity of oil left in the cakes.

At the present moment, in this country, it may not be possible to sell extracted cake for cattle feeding purposes and hence this process can at least be conveniently taken up for those oil seeds and cakes which are used for manure, and besides the extra profits made on the higher recovery of such oil, it is a definite service to the fields and the soil by giving them a proper and better manure.

Solvent extraction process can, therefore, be introduced to work side by side with the large crushing processes so that the last traces of oil could be removed from those oil seeds and cakes, which will be used as manures. This will definitely cheapen down the cost of oil production and hence the consuming public will be immensely benefited.

Alleged Objections.

There are various objections alleged against the process. Firstly it is said that this method extracts the oil so effectively from the seeds, that the cake is rendered practically useless as a feed for cattle and may at best be used for manurial purposes only. Although it may be correct to a certain extent, but it may be mentioned that experiments carried out in foreign countries show that cattle are continuously fed on the extracted cake, from a number of plants using the solvent extraction process, without any detrimental effect on their health. This point, however, is debatable but it can definitely be said, that there are distinct indications that a marked percentage of oil in the cattle

food is not of so great an advantage as it is considered to be. On the other hand it may be mentioned that although it is the fat which is a heat former in the body, yet it is the albuminoids which are the actual flesh forming part of the food ; and that extracted meals or cakes are always richer in albuminoids than the cakes produced by pressing the same seeds. Research work in U. S. A. reveals that the cooking carried out with steam during the process of deoiling renders the protein in the most desirable form for cattle feed and that it is for this reason that the deoiled cake even with negligible oil but with a better protein combination is held responsible for better production of milk and dairy products than from those cattle fed on pressed cake. Apart from this it should also be noted that no oil cake is fed alone to the cattle, but that it is always mixed with some other substances like the bran; and this other substance can to a greater extent be conveniently changed to the extracted cake, in order to give the food stuff, the desired fat content. Alternately the extraction process, under modern conditions, can very well be worked in a manner so as to leave the oil content of the cake to the desired degree.

Secondly, it is stated that it is almost difficult to eliminate entirely the last traces of the solvent from the oil and the cake so that the oil is rendered unfit for edible purposes and the nauseous taste of the cake is another factor for prohibiting its use as a cattle feed. The extracted oil is said to be of use only for technical purposes like soap making or allied industries. This is, however, a baseless allegation as there is evidence of completely eliminating the traces of solvents both from the cake and the oil. In England and America large quantities of extracted oils are being used for edible purposes as also in the manufacture of first grade margarine etc.

The third objection is about the solvents which have their own technical drawbacks. Though solvent extraction has been making a good headway, the requirements of a good solvent are still not fully met. Ether and Chloroform are too expensive to be used commercially. Carbon tetrachloride is also expensive and is apt to exercise a poisonous effect on the workers attending the plant, besides its properties of readily attacking the metals. Carbon-di-sulphide is said to be a good solvent, but it is difficult to obtain in a purer form, and the oil obtained by the use of this solvent is said to impart an unpleasant taste and colour to the soap made from it. It is readily inflammable and has a poisonous effect on the health of workers attending the plant.

Benzine is, however, the most commonly used solvent, because it is comparatively cheap and is easily available in large quantities. The last traces can be easily removed from the extracted oil, and this has a minimum tendency to dissolve the non-fatty organic matter of the seed. Its only disadvantage is its extreme inflammability. Benzine, however, is specially prepared for the vegetable oil industry and is offered by the principal petroleum companies.

Tetrachloromethane, Trichlorethylene, Ethylene Dichloride are various other solvents of recent introduction, and although they possess certain advantageous features, they are yet not widely used on commercial scale mostly on account of their prohibitive cost.

Another reason for the adoption of this method, particularly for India, is the country's climatic condition whence on account of higher temperature, the solvent losses are expected to be high. This can, however, be overcome by air conditioning the plant.

Principles

Deiss, a French Chemist, was the first man to make a solvent extraction apparatus in the middle of the past century. Since then various efforts have been made in the direction and the present process of extracting oils on the principle of SOXHLET is now successfully carried on, in many countries. No attention has, however, been given in India to the potentialities of this chemical separation of oils from the various oil seeds and cakes etc.

Referring to a general set up, the method starts with the seed, which first goes to the usual processes of cleaning, screening, separation of iron, weighment, and disintegrating or breaking up through rolls into flakes of desired sizes, effected by slightly moistening the seed before passing through rolls. The material is then passed through a traversing hopper, which feeds a number of extractors, according to the capacity of the plant. The extractor is then charged with the solvent and the oil is extracted by the solvent, in hot or cold, as desired. The oil and solvent are then passed through heat exchangers, which separates the oil, and the solvent vapours after cooling, return through condensers, and separators back into the solvent tank. The oil from the heat exchangers is then passed through filter presses to the refining tanks. The extracted cake is dropped down, dried and bagged for storage. This completes the cycle of operations.

Nature Of The Solvent

A solvent which can effectively be used in the oil extraction process must possess the following properties :—

(1) Should neither be inflammable nor explosive.
(2) Should thoroughly dissolve the oil and fats contained by the oilseed or cake under treatment.
(3) Should be volatile and should not disintegrate on distillation, the absolute volatility being useful to remove the last traces from oils and residues.
(4) Should not as far as possible dissolve other constituents of seed or cake except its fatty portions.
(5) Should not give out noxious vapours which have a detrimental effect on the life of the workers attending the plant.
(6) Should be cheap.
(7) Should be immiscible with water.
(8) Should not have any action on the metals so that the apparatus and the pipe lines etc. may not be corroded.

A solvent meeting all the above requirements has, however, not yet been found. All those described before possess one or more disadvantages. However, the most common solvents used are generally light petroleum fractions. European countries have commonly used a naphthenic base product consisting mostly of cyclo-hexane, having a boiling range of 160° to 185° F. Extraction naphthas produced in America are of various grades and consist principally of normal naphthane (boiling range 83 to 100 F.); normal hexane (boiling range 140 to 160 F.); normal heptane (boiling range 186 to 212 F.) and mixed octanes etc. Of all these the normal hexane product is generally employed by American plants. A blended product of hexane and heptane fractions may also be used but it is said that such a product generally becomes less satisfactory than any one of the pure fractions. The extraction naphthas are generally sufficiently stable to be re-used indefinitely, are cheap and easily available but suffer from a serious disadvantage of being extremely inflammable. Elaborate precautions are, therefore, necessary in the plants.

One of the main causes that had kept back the adoption of solvent extraction process in India is the paucity and difficulty of getting solvent cheap enough and in abundance. Production of

alcohol in India is now in progress and it may be possible to find out some good solvent out of the molasses distillation which can be used as suitable medium for oil extraction.

The Extraction Process

The general set up of an oil extraction plant has already been described in the beginning of this chapter. The ideal solvent extraction plant can, however, be said to be one which can secure the complete recovery of all oil in the seed in one stage and should leave the residue also in one stage. The process adopted varies with the different types of plants, as manufactured by different manufacturers, and may broadly be divided into the following three main classes :

(1) The Batch Method : Where both the extraction and the solvent recovery sections are worked in batches.

(2) The Semi-Continuous Method : Where the extraction process is semi-automatic and the solvent may or may not be recovered continuously.

(3) The Continuous Method : Where the extraction and the solvent recovery sections are both continuous and automatic.

Batch Extraction : Batch solvent extraction is principally used for the recovery of relatively expensive oils. One of the greatest advantage of this process is that it can be made to any size. Thus it would be possible to make a single batch pot extraction plant handling one cwt. of seed per batch or increase the size and number of the pots and handle thousands of tons in all per batch. Actually quantities as low as 1 cwt. per day and quantities up to 3,000 tons per week have been handled in batch extraction plants.

Batch extractors vary greatly in design, much less in their working and while batch extraction by means of percolation is satisfactory for some materials, it is not generally adoptable to large scale extraction plants engaged in the processing of various oilseeds. It is impossible to charge large extraction chambers with oilseed flakes without uneven compacting of the material and consequent channelling and incomplete extraction. Batch extractors are, therefore, commonly provided with some form of agitators to mix the solvent with the seed particles. The process essentially consists of charging the well prepared material through the large top inlet, invariably provided, the agitation gear, however, remaining stationary. Solvent is applied to

this meal after all the doors have been made fast. This solvent can be removed by a mixed solvent pump working in conjunction with a filter box and a mixed solvent tank. It should be noted that the solvent will have extracted some of the oil and the mixed solvent tank contains miscella more or less rich in oil. If this is not sufficiently rich then this mixed miscella can be put back and utilised to take more oil from the meal. If it is sufficiently enriched, then it is taken to a solvent still. This is an ordinary callandria type vessel and by means of steam the bulk of the solvent is driven off. It has been found impossible to remove all the solvent by means of closed steam and it is, therefore, necessary to finish the oil by injecting steam. This is generally achieved in a separate vessel called an oil finisher and where competition is not too keen this is probably the best way of treating the last traces of solvent remaining in the oil. Where competition is keen the injected steam can be applied to the material in the still. Whichever method is adopted the vapours from the still and the finisher are taken through a condenser and the condensate removed through a clean solvent tank in which is arranged a decantor or water separator.

When sufficient solvent has passed through the extractor to bring the percentage of oil down in the meal to that required, the whole of the solvent, which will drain, is taken off. It will be fully appreciated that quite a large proportion of the solvent will remain absorbed in the meal and injected steam is applied to the extractor when the vapour valve is open and this mixture of steam and vapour is condensed as before and passes through the decantor or water separator into the clean solvent tank. Usually it is only while steaming off that the agitators are in use and they should continue until finally the meal is free from solvent and is thrown out by means of the agitators through the outlet of the extractor and then passes to driers where the moisture condensed in steaming off is removed leaving a dry meal fit for marketing.

The Semi-Continuous Extraction Process. The last portions of miscella recovered in the batch extraction plants are generally very lean in oil and hence they can be well substituted for fresh solvent in the initial treatments of fresh seed. In this way each portion of the solvent is made to perform a double duty and the amount of solvent to be recovered from a given quantity of oil is naturally decreased accordingly. This is the principle of the semi-continuous method and is really nothing but a modification of the batch process. In this system, therefore, a battery of extraction pots similar to the batch pots are provided and

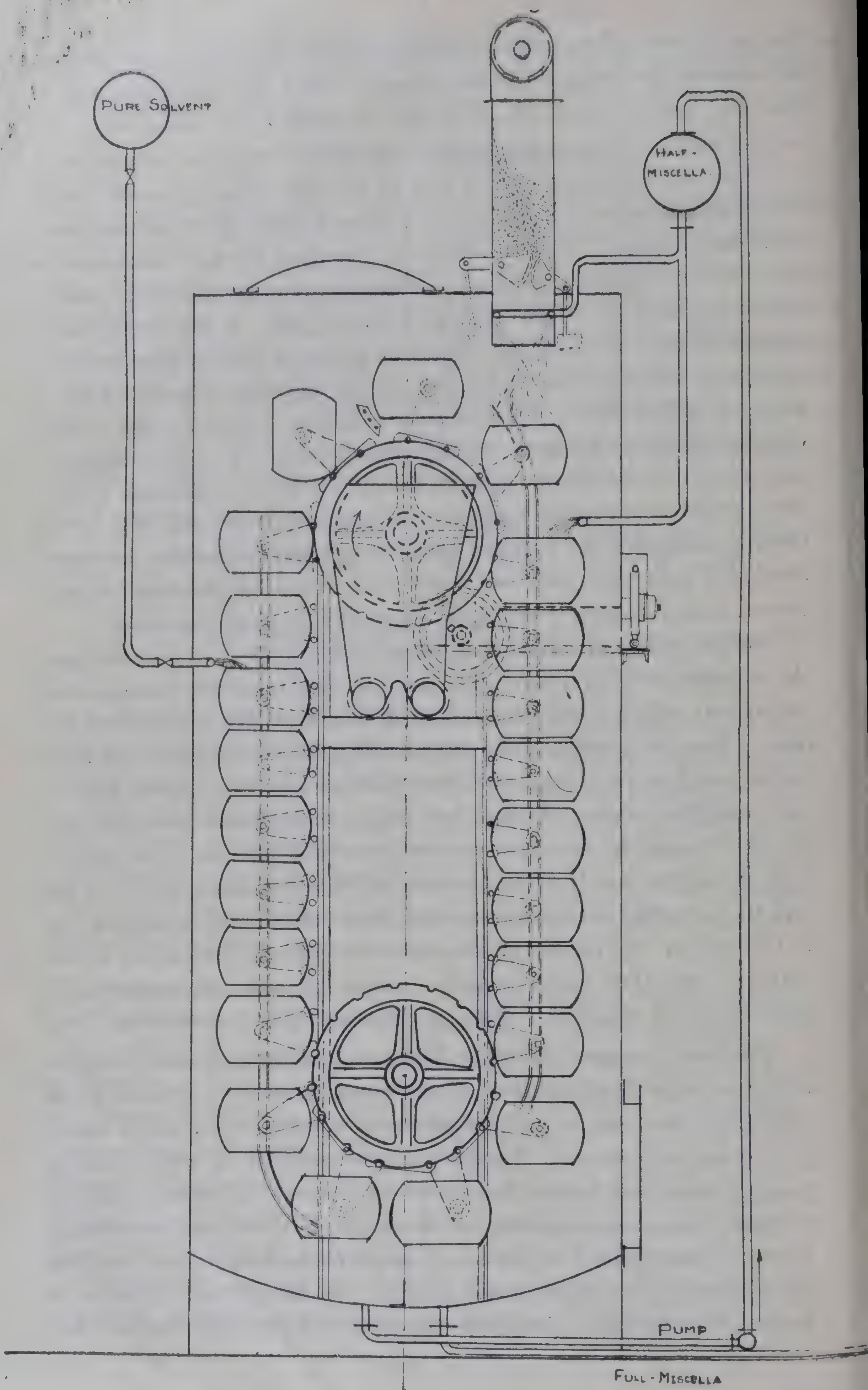


Fig. 1. The Bollman Extraction Plant.

the solvent is used to treat the contents of each extractor in succession. Each time that a batch of miscella is run out from an extractor, it is used to treat a batch of seeds which have previously been extracted with a richer miscella. On the other hand the extracted seeds are each time extracted with a thinner miscella. Thus the seeds are treated with batches of solvents having decreasing proportions of oil, until they are finally extracted with a fresh solvent and are discharged. On the other hand the solvent is brought into contact with different batches of seeds having greater proportion of oil until it finally encounters fresh seed and is then discharged as the final and finished miscella. In this way, the miscella is brought out of the system at a uniformly high oil content. This then finds its way, going through various strainers, filters etc., into a continuous still. This still can be divided into three parts. the top may be looked upon as a dry falling film evaporator. The miscella as it enters this top portion has the bulk of the solvent removed by steam heat and as this solvent is dry, it is usually attached to its own surface condenser where the clean solvent is condensed. later freed from water in decantors and then goes back to store. After the miscella has fallen through the falling film callandria at the top, it passes down a series of trays where it meets an on-coming stream of steam which robs it of the bulk of the remaining solvent and the combined steam and vapours proceed to another condenser and the water and solvent form into condensate and pass to the decantor or water separator and thence the solvent goes forward to the storage tank.

After having passed across the trays, the solvent collects in an inner ring at the bottom of the still where it is acted upon by a jet of steam which has to bubble through the bulk of the oil. Passing from this inner ring the miscella is forced to pass through a series of concentric rings in each of which it meets jets of steam and by this means, before being ready to leave the still, the oil will have been robbed of the whole of its solvent content. The oil flows from the continuous still as a steady stream and is pumped to storage tanks.

The Continuous Method. Most of the large continuous solvent extraction systems, actually operating all over the world, owe their origin to European or German designs, and are popularly known as the Bollman or Hansa Muhle method, the Hilderbrandt method, the Fauth system, the Allis Chamber Extractor etc. These systems are all almost entirely automatic and achieve the highest economy of steam,

power, labour and materials etc. Whatever may be the form of the extractor employed in this continuous system, the principle of working remains almost unaltered. In principle, the Hansa Muhle Extractor is nothing but a large size elevator which receives solvent in the top bucket containing meal, this solvent percolating through all the buckets on the side and falling out of the last bucket on that side and repeating the process on the other side. The buckets have perforated bottoms and are supported on endless chains within an air-tight housing. The buckets are very slowly but continuously moved up and down at the rate of one or two revolutions per hour. The charging hopper is provided at the top of the housing and as each bucket starts down the descending side, a fresh charge of flaked seed is automatically dropped on to it, from the charging hopper. As the buckets containing the spent flakes ascend to the top of the housing on the side opposite to the charging hopper, they get automatically inverted and dump out the contents into the discharge hopper form where they are suitably conveyed to the driers. It is, as will be seen simply the continuation of the counter flow system of extracting as described under the heading of the semi-continuous plant. In this case, however, no steaming out or removal of the solvent of the meal is done in the extractor. The seeds are washed with semi-concentrated miscella and then with clean solvent, the circulation being effected by means of a small suitable pump mounted with the apparatus.

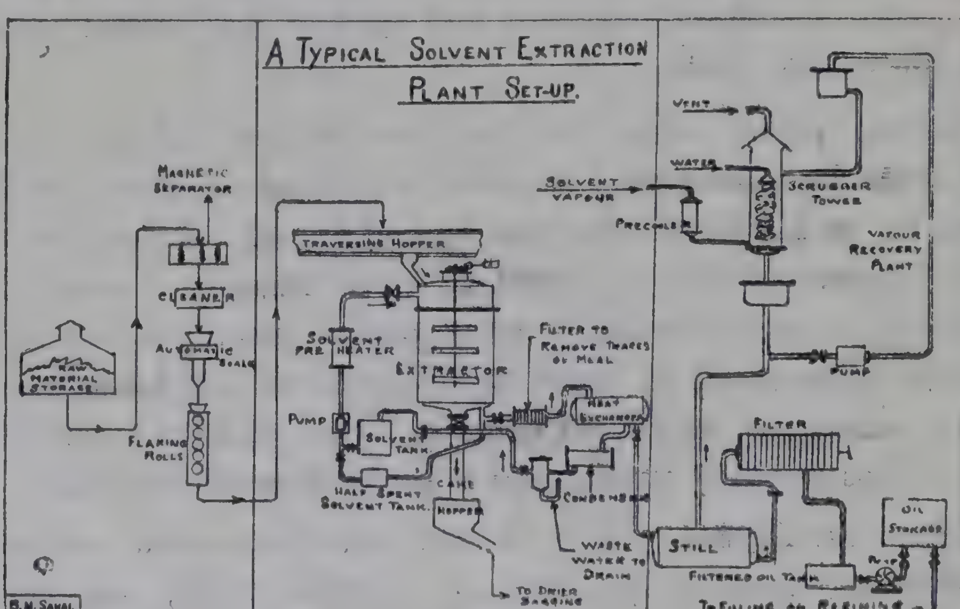


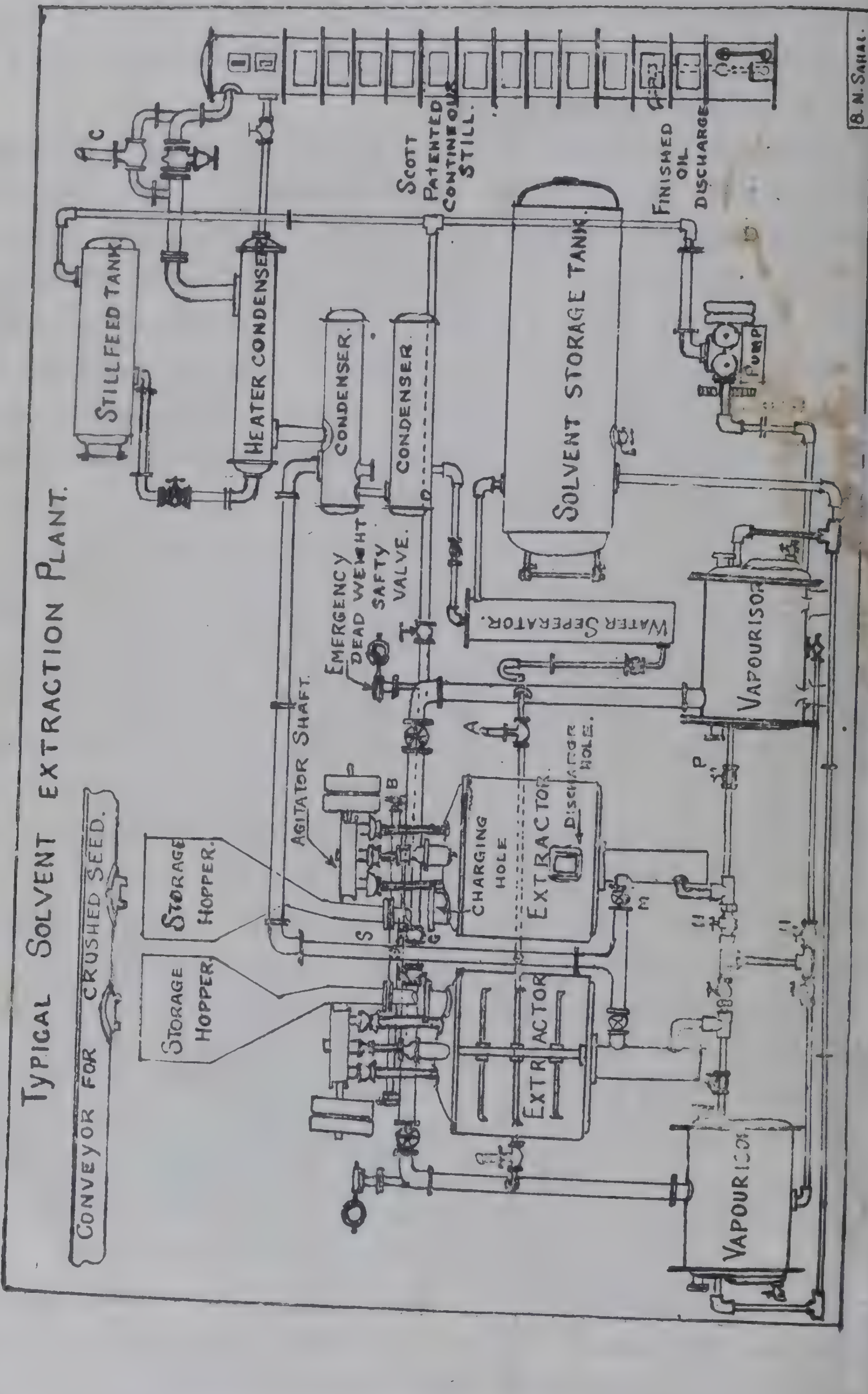
Fig. 2.

The principle of distillation of the full miscella is very similar to that employed in the semi-continuous plant, but has some modifications. In the semi-continuous plant, the strength of the miscella can be varied

very easily by adjusting the quantity of solvent passing through the vessels in series. In the purely continuous type the miscella strength is a function of the percentage of oil in the seed and must, therefore, be adjusted if a continuous still is to give a satisfactory working. It is, therefore, usual to incorporate in the continuous plants a pre-evaporator whose main work is to see that the continuous still always receives a certain uniform concentration of miscella, thus allowing steady and regular evaporation in the still.

All these methods have their own merits and demerits but usually for large scale operations, the semi-continuous or the continuous methods are supposed to work well. In order to give a clear idea about the main operations of these plants a few typical layouts are shown in figures 1 to 3 and their working may be explained as under :

The seeds to be treated are first cleaned, screened and then passed through magnetic separators to remove any iron pieces etc. In the case of bigger seeds they are first disintegrated otherwise passed to high rolls for flaking, after moistening them with a little water. They are generally not ground so finely as for the pressure method but care must be taken to reduce the meal to flakes of proper sizes and to prevent exudation of oil in passage through the rolls, in order to prevent channelling of the solvent in the extractors. The material is then passed through a traversing hopper which feeds the closed extractor vessel, cylindrical in shape and provided with suitable stirring arrangements. The solvent which is usually employed first cold and then in a warm condition is flooded into the extractor. This solvent is then removed after some time and carried to a boil, and the extractor is again filled with the second charge of the solvent. Thus nearly four charges are required to extract the whole oil from seeds. The third and fourth batches of the solvent which generally contain comparatively less amount of oil are used for the first two extractions of the next batch. Thus it will be seen that the fresh meal in the extractor is first of all exposed to the action of that solvent which has already been in contact with a partially extracted meal (3rd charge of the 1st operation) and then to that batch of solvent, which has been less frequently used (the 4th charge) and finally with two or more charges of the fresh solvent. The oil saturated solvent from the first two or three extractions is taken to a still through a filter press in order to remove the fine particles of meal. In the first instance the volatile solvent is evaporated off by heating with closed steam, when bulk of the solvent from the extracted oil is removed,



Typical Solvent Extraction Plant.

and the solvent vapours, after passing through efficient condensers are recovered and passed back to the solvent storage tank for future use.

Evaporation of the solvent becomes difficult when the ratio of the fixed oil (vegetable oil) and solvent reaches 1 : 1. At this stage the oil and the solvent mixture is removed from the first still or the "Stripping" and is taken to what is known as a plate fractionation column (still). The main and the final separation takes place in this still. This separation is a most important feature of this process as on its success and completeness depends the commercial value of the oil recovered. The still shown in figure 3 is generally called 'Scott Still' named after its inventor. This is divided into a number of sections each of which is a still by itself. The oil and the solvent mixture is first heated in the heater condenser to nearly the distilling temperatures and then enters the Scott Still from its top, passing downwards through each of the sections. At the base of this still is admitted a current of open steam, the latter passes through a baffling arrangement which causes it to take a tortuous way through the descending oil and solvent mixture. As the steam rises, it vaporises the solvent and this vapour assists the steam in distilling the solvent from the liquid passing through the next highest section of the still. The oil which is thus freed from the last traces of the solvent and is discharged from the bottom of the still, is passed through filter press, to remove the mucilage etc. as in the case of pressed oil.

Discharge Of The Extracted Meal.

When the extraction of oil is nearly completed, the residual meal which will generally contain about a per cent of oil is subjected to the blowing of dry but not superheated steam. The steam is generally admitted by opening valve V, (Fig. 3) all other solvent valves being closed. The stirrers are kept moving and the steam which takes the last traces of the solvent from the meal passes through the valve M to the pipe line S reaches the condensers and the separation taking place in the water separator. Solvent is carried to the storage tank and the water passes on to the drain. When the meal is free from the vapour, steaming is discontinued, the bottom hole of the extractor is opened and the meal is transferred by hand or gravity.

The meal is very wet due to the inevitable condensation during the steaming process. The initial content of the original meal is usually about 6 to 10 per cent. The removal of, say about 20 to 25 per cent oil would have the effect of increasing

the moisture content of the seed to as much as about 13 per cent, if no water is added or removed. On leaving the pot, the moisture content of the meal is found to be as high as 25 to 30 per cent and for all reasons this must be reduced. Various types of drying machines are used for this purpose.

All drying machines, within the range of the present subject have two features in common:

(1) Application of heat
(2) Forced draught for vapour removal.

Figure. 4 shows a view of a simple but efficient drier. The drying chamber consists of a large rectilinear housing. Three sets of specially designed horizontal scraper conveyors turn slowly in the main body, the scrapers being slung on gross beams set at intervals on a twin chain system. On reaching the end of the first scraper surface, the meal falls on to a guide plate, and as the scrapers, on the second surface change direction, the meal is taken from left to right. The cycle is repeated on all surfaces, at the end of which guide plates are provided. On the first heating surface in the diagram the steam chambers are shown. At the end of the third cycle, the meal is ejected by means of an Air Seal Feed Roll.

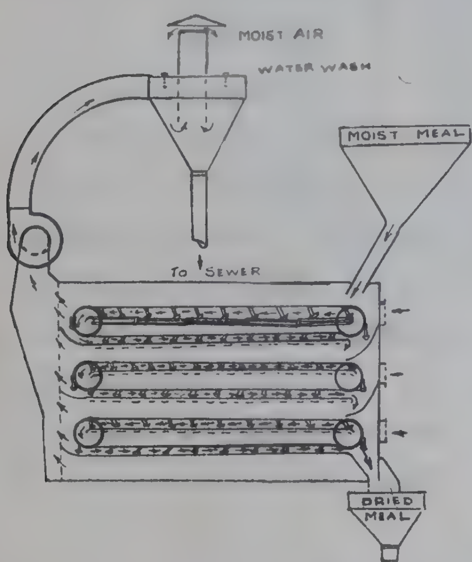


Fig. 4.

The capacity of such driers is of course a function of the size of the heating surfaces, and that machines with varying capacities are made to suit all requirements. The steam pressure generally applied is 50 to 60 lbs. per sq. inch and the meal generally leaves the chamber at about 190 to 200°F. The capacity of the machines can also be usually adjusted within limits by changing the steam pressure. The meal from the driers is then cooled to temperatures which facilitate storage.

Safety Valves.

In all plants it is considered necessary to provide safety valves at all such points where pressure might accumulat eand this also serves another purpose of providing means by which the pressure is relieved without allowing the inflammable vapour to pass on in to

the atmosphere. The points at which such pressures might accumulate to are the vaporisers, the extractors, and the still. Safety valves are, therefore, provided at A, B & C respectively (Fig. 3). The two safety valves A of the extractors are joined together by a horizontal pipe (dotted) which is joined to the pipe S. Any excess vapour passing through these safety valves does not, therefore, escape in the atmosphere but reaches the condensers. There is a similar arrangement for the safety valves B & C, the valve C being bridged over the stop valve of the still, so that the excess vapours can pass through the heater condenser to the condenser. The water can generally act as a check to any pressure developed in the storage tank or the condensers, but there are very little chances for this. An emergency dead weight valve is provided at the top of the vapour lines which can come into play if the valves 'A' may fail at any time.

An Alternative Method

It is often considered advantageous to carry out the extraction by liquid solvent and provision for this is, therefore, made in plant shown in Fig. 3; the original charge of the solvent is, however, sent through the vaporiser, which is then cut off by closing the valve P. The valves G & H are opened. The solvent and oil from the extractor can now pass through the valve W to the pump and are sent back to the extractor through the pipe line Q and the valve G. Several circulations of the solvent are given in this way, before it is sent to the still feed tank by closing the valve G.

Solvent Losses: The greatest loss of solvent which occurs in a well constructed plant of any design is due to the solvent saturating the air and coming away at the temperature of the condensate. This solvent must be recovered and there are two important methods of effecting this recovery.

The first and probably the best, is to pass the air through towers charged with activated carbon which absorbs all the solvent leaving the air free to be vented out to the atmosphere. The solvent can then be recovered from the activated carbon. These absorption towers are usually installed in pairs so that one may remain in operation while the recovery from the other is being made. The other method is to cool the air to a low temperature by means of any refrigerant and thus lose only the saturation at the low temperature employed.

Power Steam & Labour

Other points of interest in the solvent extraction plant are that of power, steam, solvent losses, labour and cooling water etc.

The power and steam consumption depend generally on the nature of the plant. The consumption of steam in the continuous process is nearly half as much less as in the Batch System. The power required for the continuous system is, however, a little more than what is re[illegible]ared for the Batch System.

As to the solvent losses they vary with the class of material, the quantity of steam used and the design and the type of the plant et[illegible] the continuous system the losses of solvent are much less than [illegible] Batch System. The losses generally should not exceed 1½ to 2 p[illegible] on the weight of the material treated.

The labour question depends on the style and set up of the [illegible] but very few labour as compared to the pressing unit is employed. [illegible] the chemical side about half a dozen men can probably look well to a plant of about 50 tons capacity. This excludes men employed on the preliminary treatment of seed like, cleaning and flaking etc. in which case the labour employed is generally on the lines of the pressing method. There is certainly a need of technical supervision of a higher degree. The consumption of cooling water is very great and equals nearly 46 tons for a 50 ton plant.

Conclusion

The initial outlay of the solvent extraction plant is generally great and the prospects of marketing the products particularly the cake for feeding purposes will be somewhat more difficult at present. The insurance charges are also much higher than the pressing units. On the other hand, the maintenance cost of the plant is very much less and the cost of the replacement negligible. It requires much less space per ton capacity, and the labour employed is also very little. The whole plant can be kept very neat and tidy, is automatic and efficient, giving a very high yield of oil. It will be seen, therefore, that the solvent extraction plant has a very distinct field of its own. It can be worked side by side with the pressing process and can be found to be of great value in certain particular cases like those of mahua and castor etc. Although there may not be great difficulties in the disposal of the oil and if side by side the true value of the extracted meal as a cattle feed and manure is recognised, the process will become a powerful rival to the pressure method of oil expression.

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